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Feasibility Study of Alternative Technology for Small Community Water Supply

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FEASIBILITY STUDY OF ALTERNATIVE TECHNOLOGY FOR SMALL COMMUNITY WATER SUPPLY

by

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Cooperative Agreement CS 809411

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16. ABSTRACT

A cooperative demonstration project was funded by the U.S. Environmental Protection Agency (EPA) to enable the Village of Cayuga, N.Y. to install and demonstrate water filtration technology that may be appropriate for small water systems that use surface water sources. A prefabricated filtration system consisting of two cyclone separators in parallel followed by three parallel treatment trains, each employing a contact clarifier, a mixed media filter, and a granular activated carbon filter was installed at Cayuga's existing water treatment plant. The new equipment replaced facilities built in the 1930's. After installation, careful records of the first year's operation were kept to document water quality, operating labor needs, and operating costs, including power and chemicals.

Data collected showed that, with respect to turbidity removal, the performance of the treatment plant exceeded the goals set forth in the study.

As for costs, chemicals totaled 5 cents per 1000 gallons, and power, including raw water pumping but excluding treated water pumping, was 10 cents per 1000 gallons, at a rate of 6.2¢ per kilowatt-hour (KWH). Installation cost for the 150 gallons per minute (gpm) system was $268,000.

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FOREWORD

The U.S. Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimonies to the deterioration of our natural environment. The complexity of that environment and the interplay of its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution; it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems to prevent, treat, and manage wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, to preserve and treat public drinking water supplies, and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research and provides a most vital communications link between the researcher and the user community.

This study was designed to evaluate the efficiency of a specific pressure filtration system that could be applied to surface waters that are subject to severe turbidity and color fluctuations. Installation and operation requirements are also addressed in this report. The results have important implications for designers, purchasers, and operators of small water supply systems.

Francis T. Mayo, Director
Water Engineering Research Laboratory

ABSTRACT

A cooperative demonstration project was conducted in the Village of Cayuga, New York, with water filtration technology that may be appropriate for small water systems utilizing surface water sources. The demonstration project was undertaken because the existing facilities of the Village of Cayuga were not able to meet the turbidity requirements established by the NYSDOH. Existing facilities at the Village of Cayuga consisted of aeration, sedimentation, and filtration. A prefabricated filtration system was installed at Cayuga's existing water treatment plant. The system consisted of two cyclone separators in parallel followed by three parallel treatment trains, each employing a contact clarifier, a mixed media filter, and a granular activated carbon filter manufactured by Culligan, USA. Careful records of the first year's operation were kept to document water quality, operating labor needs, and operating costs, including power and chemicals.

Data collected during the first 12 months of system operation showed that the filtration process could meet the 1 nephelometric turbidity unit (NTU) maximum contaminant level specified in U.S. Environmental Protection Agency Primary Drinking Water Regulations. The New York State Department of Health guideline was also met. With respect to turbidity removal, the performance of the treatment plant exceeded the goals set forth in the study.

The filtration equipment at Cayuga operates in a direct filtration mode with no settling basins. Thus all suspended solids must be removed in the contact clarifier, the mixed media filter, or the GAC filter. The study showed that when raw water temperature fell below 10 C, turbidity removal in the contact clarifier declined and turbidity removal in the GAC filter increased. Apparently more time was needed for the alum coagulant to act effectively when the raw water was cold. In addition, when the pH of the coagulated water exceeded 7.5, removal of the precipitated aluminum coagulant was less effective, and aluminum concentrations in filtered water increased. The equipment installed at Cayuga did not include provision for lowering pH for coagulation.

The 12-month study at Cayuga indicated that 2.7 hours of operating labor were needed per day. Costs for chemicals totalled 5 cents per 1000 gallons. Power costs, including raw water pumping but excluding treated water pumping, were 10 cents per 1000 gallons at a power rate of 6.2 cents per kilowatt-hour. Installation cost for the 150 GPM system was $268,000.

This report was submitted in fulfillment of Cooperative Agreement No. CS809411 by the Village of Cayuga, New York, under the sponsorship of the U.S. Environmental Protection Agency. This report covers the period of Sept. 15, 1981, to March 14, 1984, and work was completed as of July, 1984.

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ABBREVIATIONS AND SYMBOLS

APHA	American Public Health Association
ASU/ML	Areal standard unit per milliliter
BW	backwash
C	degree Celsius
ft	feet
FTU	formazin turbidity unit
g	gram
GPD	gallons per day
GPM	gallons per minute
GPM/ft	gallons per minute per square foot
h	hour
I.D.	inside diameter
in.	inch
L	liter
mg	milligram
mg/L	milligram per liter
mgd	million gallons per day
min	minute
NTU	nephelometric turbidity unit
pH	negative log of hydrogen ion concentration
$\leq$	equal to or less than
μg/L	micrograms per liter

CONVERSION FACTORS

TO CONVERT FROM	TO	MULTIPLY BY
Gallons (U.S. Liq.)	Cubic Meters	0.0037854
Gallons (U.S. Liq.)	Liters	3.7854
Gallons H_2O (U.S. Liq.)	Pounds	8.3358
Gallons H_2O (U.S. Liq.)	Kilograms	3.7854
Pounds (AVDP.)	Kilograms	0.4536
Pounds (ADVP.)	Grams	453.6
Gallons Per Minute	Cubic Meters Per Sec.	0.227
Gallons Per Minute	Liters Per Minute	3.7854
Square Feet	Square Centimeters	929.03
Square Feet	Square Meters	0.0929
Feet	Centimeters	30.48
Inches	Centimeters	2.54
Feet	Meters	0.3048
Pounds Per Square Inch	Centimeters of Hq	5.1715
Pounds Per Square Inch	Centimeters of H_2O	70.31
Pounds Per Square Inch	Kilograms Per Sq. Centimeter	0.0703

ACKNOWLEDGMENTS

This report is based on the efforts of a number of persons, agencies, and industries. It is an extension of other studies conducted on similar pressure filtration equipment to satisfy less stringent requirements in other areas of the United States.

Many contributed to the effort at the Village of Cayuga, New York. We thank the Honorable Gary Lee, Congressman from the 33rd Congressional District of New York State, for his interest in the water quality problems that existed in Cayuga. We are also grateful to the New York State Department of Health and the Cayuga County Health Department for their assistance and guidance throughout the project. Thanks are also due to New York State Department of Transportation, who supplied climatological data and other information relative to Cayuga Lake.

Considerable guidance and assistance was provided throughout the project by Culligan, USA of Northbrook, Illinois, and the Culligan Water Conditioning Service of Wayne County, Inc.

The report is based on data collected daily by the water treatment plant operator, Ms. Marlyn Salato. The accuracy and dependability of that data are a credit to her and the Village of Cayuga, New York.

The author would also like to thank the EPA Project Officer, Dr. Gary S. Logsdon, P.E., for sharing his experience, guidance, and knowledge, which have been a great help in the assembly of this report.

SECTION 1

INTRODUCTION AND PURPOSE OF STUDY

Meeting the requirements of the U.S. Environmental Protection Agency (EPA) drinking water regulations for turbidity is often economically difficult for small communities, especially in states with guidelines that are more stringent than the EPA Drinking Water Regulations. Such is the case in New York State with regard to installing filtration systems on public water supplies for the removal of turbidity. Detailed background of this study is found in SECTION 3 BACKGROUND beginning on Page 5.

EPA regulations require that a filter installed to remove turbidity produce water at or below the 1 nephelometric turbidity unit (NTU) concentration. The New York State Department of Health (NYSDOH) requires that the guidelines set forth in Table A of the Performance Criteria for Pretreatment and Filtration (see Table 1) be met when installing a filtration system on a public water supply for the removal of turbidity. The guidelines are intended to be applied to performance evaluation data obtained at water treatment plants that have design criteria differing from those in "Recommended Standards for Water Works, 1982," commonly referred to as the "Ten State Standards."

The Table A performance criteria for the filter effluent is up to five times more stringent than Federal Drinking Water Standards. In addition, Table A sets maximum concentrations for color, microscopics, and aluminum in the finished water.

Small communities find it particularly difficult to finance pilot studies of specific equipment that will satisfy these guidelines. This study was carried out to evaluate a package plant system using cyclone separators, coagulation, contact flocculation, multi-media depth filtration, and granular activated carbon filtration for effluent polishing. Water quality data and cost data were obtained for a 1-year period after the existing water treatment plant was remodeled and the new equipment was installed. This information will be valuable to many small communities contemplating installation of package plants.

TABLE 1

PERFORMANCE CRITERIA: PRETREATMENT AND FILTRATION

TABLE A

% of values	PROCESS							
	Pretreatment Effluent				Filter Effluent			
	Turbidity	Microscopics	Aluminum	Color	Turbidity	Microscopics	Aluminum	Color
	units	areal std. units/ml	mg/l	units	units	areal std. units/ml	mg/l	units
95 or more	≤ 5.0	≤ 14,000	≤ 0.70	≤ 10	≤ 0.50	≤ 1000	≤ 0.15	≤ 5
75 or more	≤ 2.3	≤ 9,000	≤ 0.45	≤ 10	≤ 0.30	≤ 400	≤ 0.09	≤ 5
50 or more	≤ 1.0	≤ 6,000	≤ 0.30	≤ 10	≤ 0.20	≤ 300	≤ 0.05	≤ 5
AWWA Goals (for comparison) →					≤ 0.10	no live organisms	≤ 0.05	≤ 3

4/24/75

Water Supply Design & Construction Section
Bureau of Public Water Supply
New York State Department of Health

SECTION 2

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations have been made based on the data collected for this study.

1. The reduction of contact time of coagulation and flocculation chemicals achieved by the contact clarifier greatly reduces area requirements for this in-line pressure filtration system. Consideration must be given to a minimum coagulation contact time of 10 minutes during periods when raw water temperatures are 10°C or less to prevent precipitation of floc downstream of final filtration units.

2. Coagulation pH at Cayuga must be maintained between 6.5 and 7.5 to prevent the breakthrough of both aluminum and microscopic particles in excess of NYSDOH Table A guidelines.

3. The two-stage coagulation-flocculation chemical feed system was capable of reacting to extreme turbidity changes in this filtration system. The finished water turbidity concentrations were somewhat erratic when the raw water turbidity was at or near the chemical feed system's turn-on set point of the number two chemical pumps that were used when higher chemical doses are needed. This caused some fluctuations in the finished water turbidity. Though this condition did not contravene water quality requirements, the use of proportional feed equipment should be considered. Proportional feed equipment did not appear to be cost effective for this installation, but it may be at other sites or at sites requiring volumes in excess of 216,000 GPD.

4. Close monitoring of both color and total microscopic count in the finished or filtered water was necessary to determine the approaching need to chemically cleanse the carbon filters in this system.

5. In the absence of grit or gross solids with specific gravity somewhat greater than 1.0, no advantage appears in incorporating the cyclone separators in the filtration system.

6. Orifice-type flow restrictors commonly used in the type of equipment installed in this study must be incorporated in the design of the system. Their use presumes that certain operating parameters exist, which if not met may well result in contravention of operating criteria and cause failure within the system. For larger systems, consideration should be given to the use of

self-adjusting flow control devices. These types of devices would improve operational characteristics but are far more expensive to install.

7. Where it is possible to use existing structures, the type of system used for this study is often more readily adapted to installation with a minimum of structure retrofitting.

8. This type of filtration system is well suited to very small public and private potable water supplies. This type of prefabricated, modular filtration system can be assembled to deliver filtered water at low rates of 21,600 gallons per day (GPD) to 2.5 million gallons per day or more.

9. Because turbidity in water has many causes, pilot studies should be conducted to determine the suitability and capability of any equipment being considered to provide the maximum return on system installation and operation dollars.

10. The carbon selected for the carbon filters at this study was selected for polishing or removing turbidity and color from the effluent of the mixed-media filters. The material has a hard finish that was not intended for organic removal application. If organics are a major consideration at other sites, then other more suitable types of carbon should be considered.

11. The system was able to exceed federal drinking water guidelines and to meet NYSDOH guidelines for filtering of surface water supplies at filtration rates of 7 GPM/ft^2 in the primary filters and 5 GPM/ft^2 in the carbon filters. As with any filtration system, proper maintenance, monitoring, and operation are necessary for meeting the public health guidelines.

12. Operator time requirements, chemical costs, and maintenance costs during the 12-month study period appear to be within the limits of small community budgets. The limited extent of automation used at this installation reduced the need for a full-time operator on site.

13. Consideration should be given to automating the carbon filter backwash. The final turbidimeter signal as well as the pressure differential through the carbon filters should be used to initiate backwash. Pressure differential alone is considered sufficient to maintain primary filtration vessels. This is considered appropriate only when carbon or other secondary filtration equipment is used.

SECTION 3

BACKGROUND

SITE

The Village of Cayuga, located on the east shore near the north end of Cayuga Lake in New York State, is a community that was under mandate from the NYSDOH to upgrade their water supply treatment facilities. Intermittently, the finished water discharged to the distribution system contained turbidity levels as high as 20-30 NTU. With these conditions the water was not even aesthetically suitable for laundering, much less as a potable water supply. Many people within the community were, in fact, obtaining water for drinking and culinary purposes from surrounding communities and other water supplies.

The original water treatment system was installed in 1935. It consisted of a shallow water intake in Cayuga Lake, low lift pumps transferring the lake waters to an aeration chamber with 20 minutes detention time. The waters then flowed by gravity through a 27,000 gallon capacity sedimentation basin having a minimum detention time of 3 hours. The settled waters were then discharged by gravity into two rapid sand filters, each 5 x 7 feet, at the filtration rate of 2 GPM per square foot. The filter waters discharged by gravity to a below grade clear well. Backwashing was done by a separate pump taking suction from the clear well and backwashing one filter at a time at the rate of 12 GPM/ft^2 or 400 GPM. The backwash waters were discharged directly to Cayuga Lake. Chemicals used for the treatment of the waters daily were 4-5 lbs. alum, 2 lbs. powered carbon, 3 oz. ammonium sulphate, and 3 to 4 oz. of liquid chlorine. Average water consumption by the Village of Cayuga during summer months was 32,000 GPD and 13,000 GPD during the winter months. The filter cycles were 20 to 39 hours between backwashing.

WATER SUPPLY CHARACTERISTICS

Cayuga Lake, which is one of the Finger Lakes located in Central New York State, is approximately 45 miles long and 2-3 miles wide at its widest point. It is surrounded for the most part by farm land, a number of small communities, the City of Ithaca, salt mining operations, and one large power generation

station. The north end is quite shallow, averaging 5-10 ft. of depth for a distance of about 5 miles from the outlet. This shallow end has a channel that has been dredged as part of the New York State Barge Canal and is about 12 ft. deep and approximately 100 ft. wide.

The north end of Cayuga Lake is subjected to a number of conditions that affect the water characteristics. Storm water run-off causes high turbidities along the shoreline which tend to migrate northerly towards the outlet. The highest levels of turbidity have been recorded during these periods, up to 150 NTU. Substantial turbidity concentrations are caused by south winds which have the full length of the lake to generate the greatest impact of wave action at the north end and can do so in short time intervals. Elevation of turbidity concentrations from 3-4 NTU to 50-60 NTU in 2-3 hours during strong south winds is not uncommon at the intake structure at this site.

The Barge Canal system is utilized by the New York State Dept. of Transportation as a means of flood control, particularly in the control of high spring runoff due to snow melt in the Central New York region. This is done by lowering the lake level in the late fall of the year to provide adequate spring impoundment to control drainage stream channels in the canal network. After the seasonal high water levels recede, the canal system is prepared for summer traffic. This procedure requires equalizing canal system component levels and very often causes a reverse flow of water in the channel and north end of Cayuga Lake which results in high turbidity concentrations. Figure 1 shows the raw water turbidity during this study period.

The north end of Cayuga Lake is adjacent to the Montezuma Federal Migratory Waterfowl Sanctuary. The waterfowl tend to start arriving in the area before the ice has melted at the sanctuary in the spring. As a result, the waterfowl feed in grain fields around the lake in the daytime and nestle on the open water of Cayuga Lake at nighttime. As the ice recedes northerly in the spring, the waterfowl advance north until they can move into the sanctuary. This causes large numbers of waterfowl to be in the water near the intake structure for periods of up to one month. Although this condition does not necessarily cause turbidity it has caused a substantial rise in the chlorine demand of the raw water, also color concentration of the raw water is higher during this period.

During the warmer months there is a substantial weed growth in the area of the intake structure. This tends to blind the intake screen causing loss of suction of the low lift pumps and frequent backwash of the intake screen. Also during this period the pH of the raw waters becomes elevated to as high as 8.8 pH during prolonged periods of no rain. Wintertime pH concentrations are normally 7 pH or slightly below.

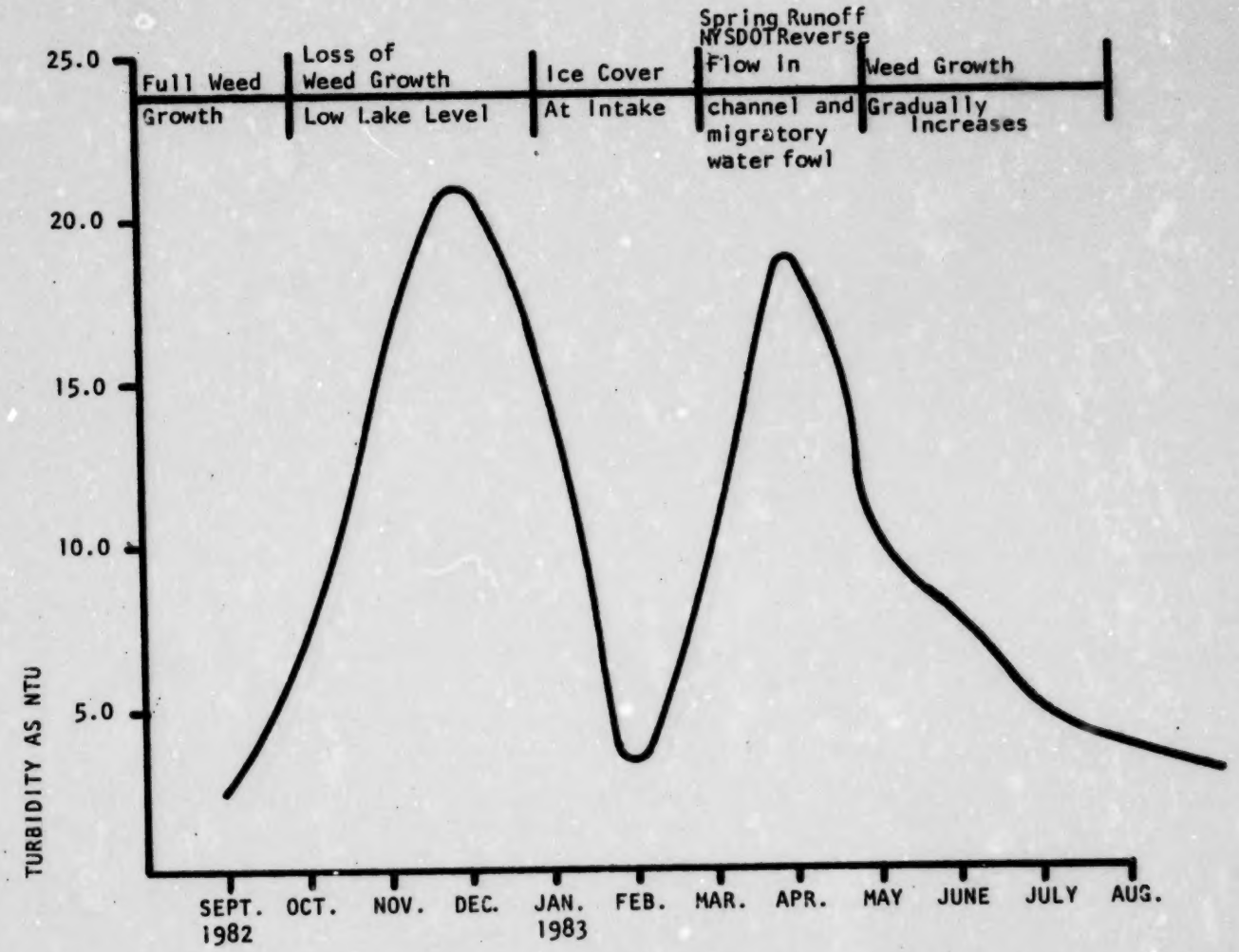


FIGURE 1 AVERAGE MONTHLY RAW WATER TURBIDITY PROFILE DURING TEST PERIOD

The raw waters are relatively hard due to calcium concentrations. The presence of other hardness cations is well below acceptable concentrations as set forth in the NYSDOH Sanitary Code Part 3 and, in general, the water quality is quite good except for turbidity at times. Results of Sanitary Code Part 5 Analysis is shown on Table 2.

NYSDOH SANITARY CODE PART 5 COMPLIANCE

Results of off-site laboratory analysis conducted twice during the study on raw waters in compliance with NYSDOH Sanitary Code Part 5.

TABLE 2. NYSDOH CODE PART 5 COMPLIANCE

Parameter Part5	Unit	8/25/82	4/27/83	Requirements NYSDOH Sanitary Code
Arsenic	mg/L	< 0.01	< 0.01	0.05
Barium	mg/L	< 0/01	< 0.1	1.0
Cadmium	mg/L	< 0.01	< 0.01	0.010
Chromium	mg/L	< 0.01	< 0.01	0.05
Flouride	mg/L	< 0.3	< 0.1	2.20
Lead	mg/1	< 0.01	< 0.01	0.05
Mercury	mg/L	< 0.5	< 0.0005	0.002
Nitrate	mg/L	< 0.01	0.4	10.0
Silver	mg/L	< 0.01	< 0.01	0.05
Selenium	mg/L	< 0.01	< 0.01	0.01
Chloride	mg/L	65.0	54.0	250.0
Copper	mg/L	< 0.01	< 0.01	1.0
Iron	mg/L	0.03	< 0.01	0.3*
Manganese	mg/L	< 0.01	< 0.01	0.3*
Sodium	mg/L	36.0	41.0	NDL**
Sulfate	mg/L	61.0	42.0	250.0
Zinc	mg/L	< 0.01	< 0.01	5.00
Corrosivity		-0.08	-0.26	Non-Corrosive
Calcium	mg/L	35.4	29.0	NDL**
Total Dissolved Solids	mg/L	250.0	170.0	NDL**
Total Alkalinity	mg/L	120.0	110.0	NDL**
pH	S.U.	7.8	8.0	NDL**
Calcium Carbonate	mg/L	--	72.4	NDL**

*Combined shall not exceed 0.3 **No Designated Limit

PRELIMINARY WATER QUALITY PROBLEM INVESTIGATIONS

The Village of Cayuga in an attempt to correct its water quality problems investigated the possibility of developing a ground water supply. A number of test wells were drilled and the quality or quantity of groundwaters found was not suitable for a public water supply.

To utilize equipment anticipating the approval of NYSDOH for turbidity removal would have required abandoning the existing water treatment plant building and construction of an entirely new building. Since there was insufficient area at the site of the existing water treatment plant for construction of a new treatment building, it would be necessary to procure additional land for that purpose. The cost of this method of accomplishing a suitable treatment for the water supply was beyond the financial capabilities of the Village of Cayuga.

A second method proposed by the consulting firm of John S. MacNeill, Jr., P.C. was to install pressure filtration equipment in the existing structure. A preliminary engineering study indicated that this method was feasible.

After studying the problem, the USEPA entered into an agreement with the Village of Cayuga to participate in a study of the capabilities of the filtration equipment proposed by the consultant. Because the proposed system for the Village of Cayuga was based on 150 GPM or 216,000 GPD, it was decided that a full-scale evaluation would provide meaningful data. Since operational costs for small communities are often as difficult to cope with, on limited budgets, as initial construction and installation costs, the study was designed to identify the system's capability to produce high quality water and also to provide operational cost data. This would assist other communities that might be considering filtration systems, in determining the feasibility of operating such systems.

SECTION 4

THE SYSTEM

The study system consisted of filtration equipment furnished by Culligan Corp. and other equipment discussed in the following sections.

LOW LIFT PUMPS

Two low lift pumps take suction from a prime tank that was part of the original intake system. Each of these pumps is capable of delivering 150 GPM through the filtration system to the clear well. One pump is manually assigned as work pump and the other is on standby.

DEAERATION AND FLOW SWITCH

Waters from the low lift pumps are discharged to a deaeration chamber that is incorporated in the original prime tank and is equipped with an air relief valve. The waters then pass through a check valve and through a flow switch. The flow switch energizes the chemical feed system and also serves as a shut-off for the low lift pump if it loses its prime.

GROSS SOLID SEPARATORS

Following the flow switch the raw water stream is split and directed to two cyclone style separators. Flowing at the design rate of 75 GPM, each of these separators has a pressure loss of about 9 psi. They have 2-inch inlet and outlet piping. The diameter is 8-inches and the length is 35-inches. The purpose of these units is to remove gross solids from the raw water stream, especially fine sands and silts that occur during high levels of wave action. These separators are equipped with drains to remove entrained solids. This is a blowdown operation which is accomplished by a pneumatically operated diaphragm valve. Air pressure to this valve is controlled by a solenoid valve which is activated by a time clock.

CHEMICAL ADDITIONS

The lake waters leave the separators and are then treated with chemicals, first alum, and then polymer. The coagulation chemical feed system consists of an alum solution storage tank, a polymer solution storage tank, each having a holding capacity of 100 gallons. Mounted under each of these tanks are three piston style feed pumps each capable of pumping 156 GPD maximum and fully adjustable by stroke length down to 5% of the maximum flow.

RAW WATER TURBIDIMETER

As mentioned earlier in this report, the turbidity of the lake waters can rapidly increase in a short period of time. To deal with this problem a small stream of incoming raw water is passed through a surface scatter style continuous turbidimeter with a range of 0-100 NTU. This unit transmits a signal proportional to the turbidity concentration. When this signal currently is below 35 NTU only one alum pump and one polymer pump are in operation. When the raw water turbidity exceeds 35 NTU an electrical contact closure starts the second alum pump and polymer pump, doubling the feed of these chemicals. Another pump is on standby. The feed rate for these chemical solutions will be discussed in detail further on in this report.

PRIMARY FILTER TRAIN

The chemically treated raw waters then enter a manifold equipped with three 2-inch outlets. Each outlet feeds a primary filter train at 50 GPM consisting of a 36-inch diameter contact flocculator (clarifier) and a 36-inch mixed media filter. The design filter rate in both of these vessels is 7 GPM/ft^2.

The clarifier bed consists of 40-inches of coarse sand with a nominal particle size of 2 mm with an underbed of granite and gravel. The interstitial voids of this media cause the mixing and flocculation of the chemically treated raw waters in the upper region of the bed. The clarification occurs in the lower portions of the bed as the flocculated particles collide with the media. Because the process takes place within the bed it appears to reduce surface blinding and extend the filter cycles. The retention time through the clarifier is about three minutes, which greatly reduces the area requirements for primary clarification. Following the clarifier the coagulated waters flow through the mixed media filter mentioned above. This filter has a triple media bed with an overall depth of 32-inches. The top layer is anthracite, the middle layer is aluminum silicate, and

the bottom layer is garnet. The underbed of this filter is also gravel and granite. The particle sizes and specific gravity of the triple media bed vary so that the coarser materials are at the top with particle size decreasing as the waters progress down through the bed. This arrangement of the bed allows the bed to capture particles throughout the depth and prevents early blinding of the filter surface resulting in short filter runs.

BACKWASH CONTROL

Each of the three preliminary filter trains described above is equipped with a pressure differential switch. This switch senses the pressure just upstream of the clarifier and just downstream of the mixed media filter. When one of these switches senses a predetermined pressure differential it closes and initiates a signal from the master control panel which is received in the slave or control panel of the No. 1 designated primary filter train. The signal is captured in the slave panel to allow the other two primary filter trains to remain in operation delivering two-thirds of the rated filtration flow to the clear well.

PRIMARY FILTER TRAIN BACKWASH CYCLES

After the slave control panels isolate their filter train they cycle the backwash operations using adjustable timers which control solenoid valves which, in turn, operate pneumatically powered diaphragm valves.

First, the clarifier is backwashed using the coagulated raw waters for 4 minutes at 90 GPM. Since the pressure loss thru the clarifier is less during backwash the low lift pump delivery rate increased which resulted in a minimal reduction of the flow thru the remaining primary filter trains that were still in the service mode. At this point a valve is opened allowing ambient air to be mixed with the backwash waters using a Venturi style ejector. This water and air mixture agitates the media for a period of 4 minutes. Following this the clarifier is again backwashed with chemically treated raw water for an additional 4 minutes. At this point the clarifier is isolated by the slave control panel and the mixed media filter is backwashed using chlorinated clear well water for 6 minutes at the rate of 90 GPM. Treated water is supplied by a short stemmed verticle turbine pump taking suction from the clear well. The pump starter coil circuit is energized by a slave control panel contact closure.

The regulation of the backwash flow is controlled by orifice type flow restrictors installed at the point of discharge from the filter vessel into the backwash drainage system. The final cycle of primary filtration vessels is the filter to waste mode

which conditions the bed preparatory to the service filtration mode. This last cycle is for 4 minutes.

FLOW CONTROL

Waters leaving the mixed media filter during the service filtration mode flow through an orifice flow meter. The pressure drop across the orifice converts readily to GPM and a valve near the flow meter at each train is used to limit and balance the flows through each train. The waters from each primary filtration train are then collected in a manifold and carried to the final filtration component at this installation.

CARBON FILTERS

The final filters are carbon filters, of which there are three. They are dual media as there is a 24-inch bed of carbon on top of a bed of fine garnet with an underbed of gravel and granite. These vessels are 42-inches in diameter and were designed to filter 50 GPM each, the design filter rate being 5 GPM/ft^2.

CARBON FILTER BACKWASH

The carbon filter backwash is manually initiated by the operator, the control panel then automatically steps each filter individually through the cycles. This is done when the pressure differential or drop through the vessels reaches a predetermined point. One vessel at a time is backwashed allowing the continued production of two-thirds of the filtered water to be delivered to the clear well during the backwashing period. The filter being backwashed is isolated from the system by air-operated diaphragm valves which caused a slight rise in pressure in the influent manifold to the carbon filters. This resulted in a slight increase in flow through the two filters remaining in service but did not cause a contravention of water quality requirements.

The backwash cycle for each of the three vessels consists of a six minute backwash utilizing chlorinated clear well waters. The backwash pump taking suction from the clear well is started by a micro switch closure in the filter control panel which energizes the starter coil as mentioned above for the primary filtration vessels. After the backwash is complete, then the vessel is operated on a filter-to-waste mode for six minutes to clean and reset the filter bed prior to the service filtration mode.

The backwash flow rate is 150 GPM or 15.6 GPM/ft^2 to assure a high level of cleaning of the media. Again, flow restrictors were installed to regulate the flow of backwash and filter to waste cycles. Water leaving the carbon filters flows through orifice type flow meters and valves. These are used to regulate and balance the flow through the carbon filters.

At this point downstream of the filtration equipment a sample stream is taken from the filtered waters prior to the injection of sodium hypochlorite solution. This sample stream flows through a bubble trap and then through a turbidimeter chamber where the turbidity is continuously sensed and recorded. If the finished water turbidity elevates to a set point, this causes a closure that initiates the backwash cycles in the primary filtration trains.

Figure 2 shows the turbidity removal capabilities of the system and the various components. A schematic drawing shows this filtration system on Figure 3. Figure 4 shows the filter and backwash daily volumes used.

The initial small scale pilot study conducted prior to the installation of this full-scale study indicated an alum dose rate of about 30 mg/L would be required. The polymer, which is a medium cationic polymer Culligan No. F-86, was determined to be approximately 1.0 mg/L. As both solutions were to be stored in 100 gallon solution tanks, the strength of the solution was calculated on producing 130,000 GPD of water using something less than 100 gallons of alum or polymer solution. Solution tanks would therefore need to be filled only once per day maximum.

SUPPLEMENTAL CLEANING OF THE CARBON FILTERS

It was anticipated that in time the carbon filters would accumulate a biological mass in the carbon bed. Even though the backwash waters are chlorinated from the clearwell, the carbon adsorbs the chlorine residual which prevents it from sanitizing the carbon bed. Therefore, an alternate method of cleaning the carbon filters was designed into this installation.

CLEANING SYSTEM EQUIPMENT

This system consisted of a 100 gallon solution tank and a piston style chemical feed pump. The discharge from the feed pump is directed to a point just prior to the inlet of waters into the carbon filter during the normal filtration mode. The chemical solution consists of 1 part 50% sodium hydroxide to 3 parts water. This represents a solution of 241 g/L or 241,000 mg/L as NaOH.

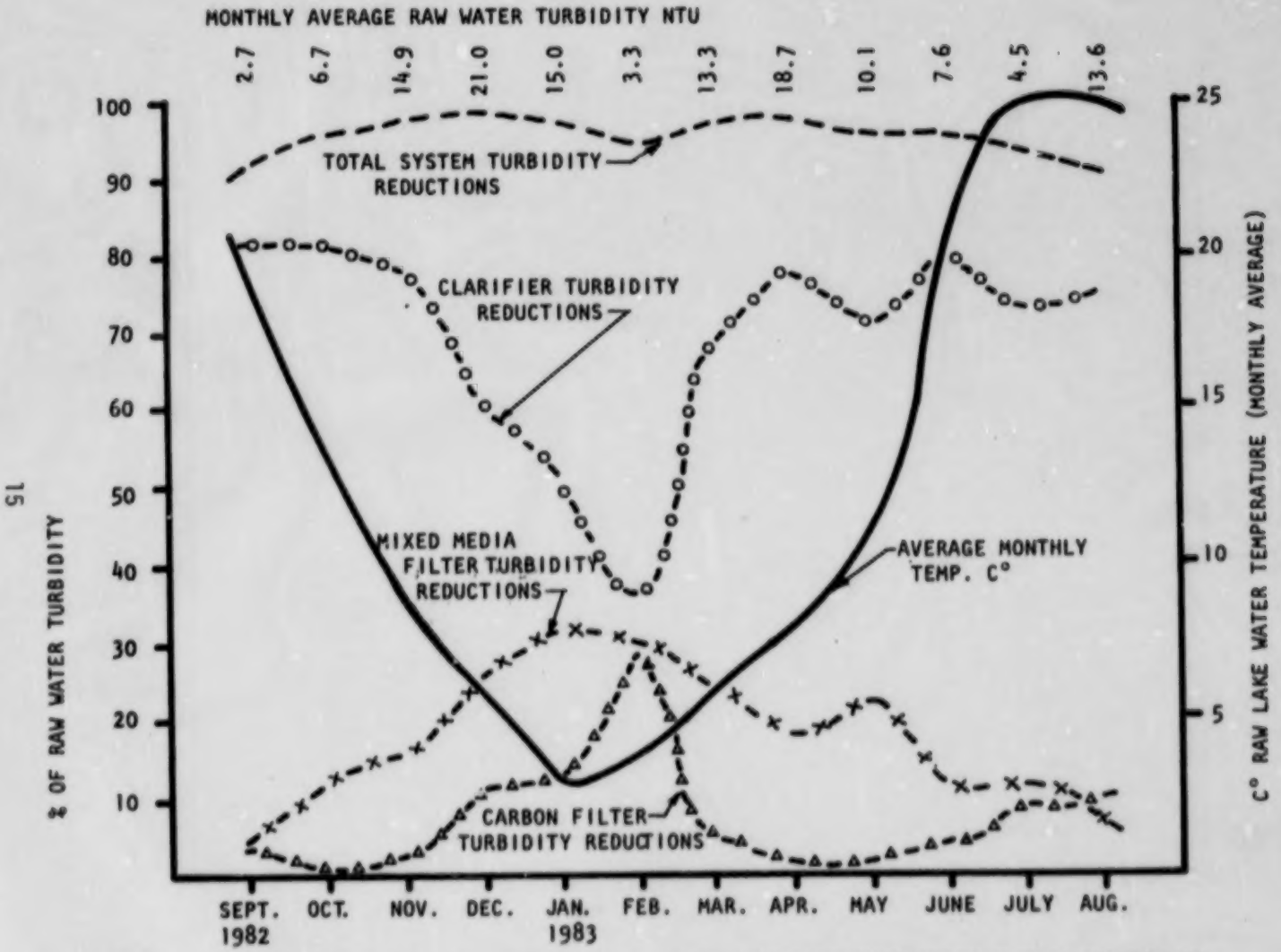
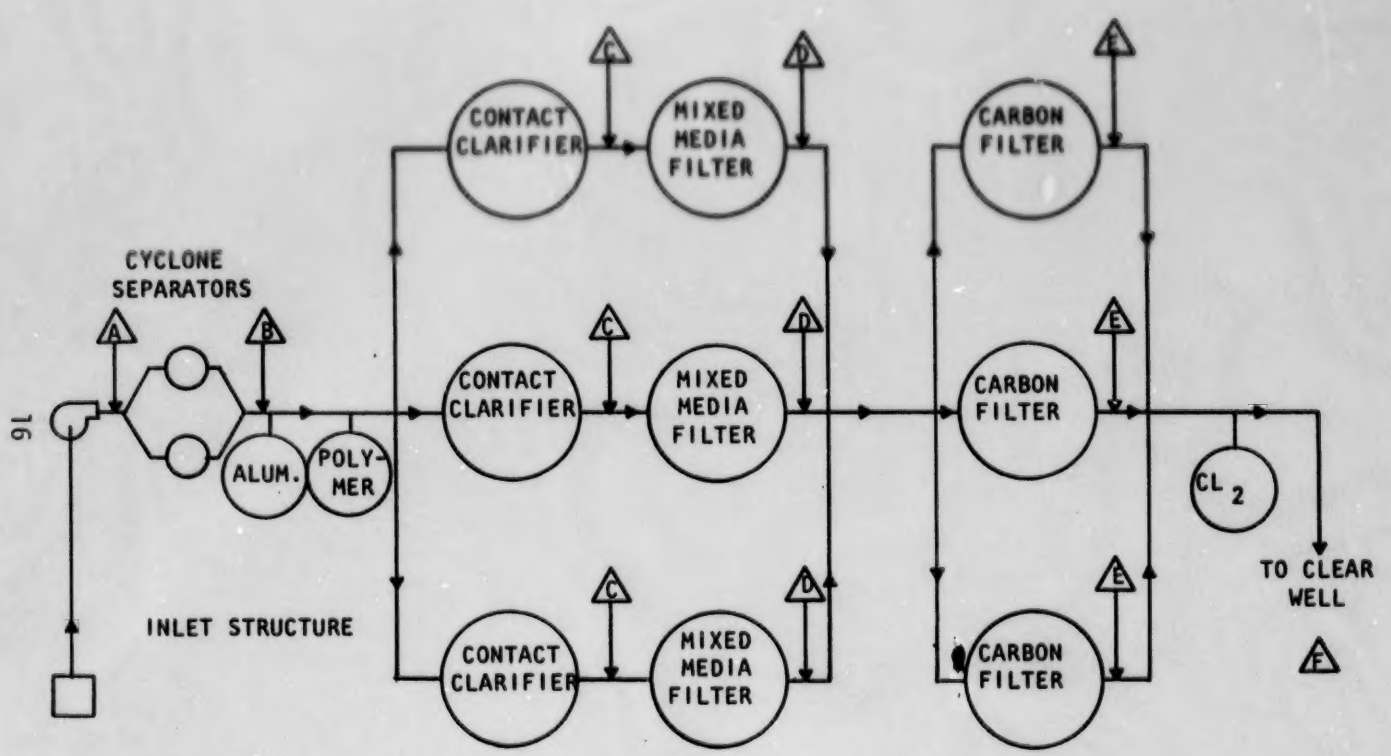


FIGURE 2 RELATIONSHIP OF TURBIDITY REMOVAL CAPABILITIES OF FILTRATION SYSTEM COMPONENTS AND LAKE WATER TEMPERATURE.



△ DENOTES SAMPLING POINTS

FIGURE 3 PILOT STUDY PRESSURE FILTRATION SYSTEM SCHEMATIC

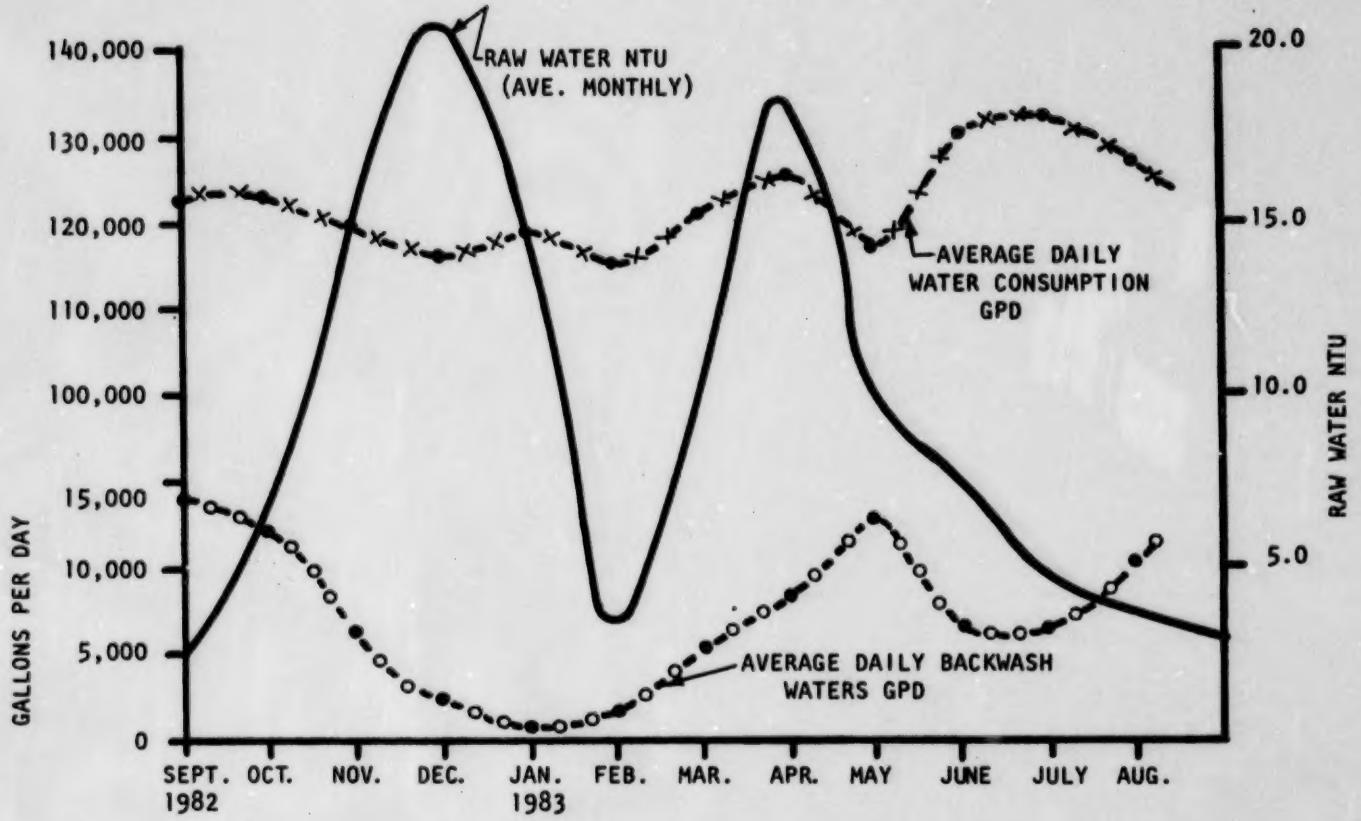


FIGURE 4 RELATIONSHIP OF AVERAGE RAW WATER TURBIDITY, DAILY WATER CONSUMPTION, AND BACKWASH WATERS USED

CLEANING PROCEDURE

The need for supplemental cleaning of the carbon filters is determined by the operator by monitoring the color reduction through the system. When there is no reduction of color through the carbon filters, or in fact a slight rise, then this supplemental chemical cleaning procedure is implemented as follows. The control panels are manually set in the filter-to waste mode after the normal backwashing cycle is complete. The sodium hydroxide solution pump is then manually turned on and the effluent from each of the carbon filters is analyzed for pH concentration. When the effluent in each vessel is elevated to 12.0 pH then the system is backwashed. The filter is then stepped through to the filter-to-waste mode. The effluent from each carbon filter is monitored for pH, color, and turbidity until the waters satisfy the operator that the carbon bed had been cleaned. Generally this is when the filter to waste waters have an NTU concentration of not more than 0.2, pH is equal to filter influent, and color is less than one unit.

This process proceeds until all the carbon filters yield acceptable waters. During the cleaning process the discharge to the clear well is shut off to prevent any waters inadvertently from contaminating the clear well and/or its waters.

A typical period that signaled the need for chemically cleaning the carbon filters, due to breakthrough of color, is shown in Table 3.

TABLE 3. COLOR MONITORING FOR CARBON FILTER CLEANING

COLOR AS APHA UNITS

Raw Water	Clarifier Eff.	Mixed Media Eff.	Carbon Eff.
30	10	8	8
10	3	2	1
8	5	6	4
9	3	2	2
Carbon Filters Cleaned			
45	8	0	0
10	4	1	0
7	3	1	1
12	2	0	0

SECTION 5

INSTALLATION OF FILTRATION EQUIPMENT

NYSDOH INSTALLATION REQUIREMENT

As a requirement for the installation of this equipment, the NYSDOH mandated that at no time during the installation would the production of potable water be interfered with for a period in excess of 24 hours. In addition, during this installation period the treated water utilized by the Village of Cayuga must never be of a lower quality than the existing system was historically capable of delivering.

SYSTEM INSTALLATION

The existing potable water treatment plant building was constructed with a clearwell below the grade floor of the building. The grade floor, or first floor (called the Pump Room), contained the pumps for transfer of lake water to an aerator chamber which opened to the second floor directly over the Pump Room. Also, the high lift pumps to inject treated waters into the distribution system and the original filter backwash pumps were located in the Pump Room. The Pump Room measured approximately 16'0" x 20'0".

The second floor is equal in size to the Pump Room and is called the Operating Room. In addition, the aerator chamber and existing filters were located at the north end of the Operating Room and adjacent to each other. The aerator chamber and existing filters were open with a curb between them and the Operating Room floor, and represented a combined area of 8'0" north to south and 20'0" east to west.

It was determined that the cyclone separators would be located in the Pump Room. The depth clarifiers and the mixed media depth filters, a total of three parallel trains, were installed on the structurally reinforced floor of the Operating Room on the second floor. Sufficient room was available in the Pump Room to install new lake suction pumps and a backwash pump taking suction from the treated water in the clearwell. This work was accomplished without interruption to the Village of Cayuga water supply. The construction-installation phase of the project started on March 10, 1982 and the switch-over to the new partial filtration system occurred on June 14, 1982.

The switch-over to the new partial filtration system was accomplished in 12 hours. Then the new system was started up and the chemical feed system started. Filtered and chlorinated water samples were collected continuously and analyzed until a stabilized flow of water containing turbidity concentrations equal to or less than USEPA potable water guidelines was achieved. At this time the filtered and treated water was discharged to the clear well which filled to capacity in less than two hours.

A final check of the quality of the water in the clearwell revealed a stable chlorine residual and the distribution system's high lift pumps were turned on. The total shutdown period required for switch-over was just less than 16 hours. The installation of the carbon filters which completed the filtration system for this study was complete by August 24, 1982 and the full system was operational August 26, 1982.

SECTION 6

PILOT STUDY DATA COLLECTION PROCEDURES

FLOW MEASUREMENTS

A flow measuring device for each train combination of clarifier and mixed media filter was installed for visual recording and flow balancing. Also, flow measuring devices were installed following each carbon filter.

These measuring devices consist of pressure differential gages which measure the pressure drop across an orifice that does not exceed 80% of the pipe diameter. These gages indicate inches of head as a differential pressure. The operator daily logged both the pressure differential to the nearest gage interval and the GPM.

These gages were calibrated using the time and volume method and are equipped with zero and range adjustments. The gage is accurate to within 2% of the range. This calculates to an accuracy of within 1.0 GPM for the 1-1/2" orifice in a 2" pipeline, or 0.5 GPM for the 1-3/4" orifice in a 2-1/2" pipeline, at 50 GPM flow.

The flow gages were calibrated at 2 month intervals to determine the impact of either impingement build-up or velocity wear on the orifices. The only problem encountered with the orifice type flow gages was the accumulation of sediment in the gage tap holes in the flanges during the cold raw water period when after-floc was occurring downstream of the primary filter trains. This condition interfered with the accuracy of flow gages following the mixed media filters. Cleaning with a bristle type pipe cleaner quickly restored accurate readings.

The finished chlorinated water that is injected into the distribution system of the Village of Cayuga is measured by an existing vane type water meter. Readings from this meter were logged daily by the treatment plant operator.

FILTER UNITS HEAD LOSS

The head loss across each vessel in the three trains is measured by visual gages installed at the points just upstream,

and just downstream of each vessel. This data was logged by the treatment plant operator two times each day. These gages were also used to calibrate pressure differential switches that energized the backwash cycles in the primary filter trains.

TURBIDITY

A portion of raw water entering the system from the Cayuga Lake intake continuously passes through a "Surface Scatter 5" Turbidimeter, a product of the Hach Chemical Co. This sample stream was taken after the cyclone separators and prior to coagulation chemical injection as the preliminary small scale pilot study indicated little or no turbidity change occurred through the cyclone separator although substantial gross suspended solids were extracted by the separator. It was felt that this location reduced maintenance time for cleaning the "Surface Scatter 5" turbidimeter. The proportional signal value from this unit is recorded on a continuous strip chart.

A portion of the filtered water following the carbon filters, but prior to chlorination, continuously passes through a Model 1720-A turbidimeter, a product of the Hach Chemical Co.

Both of the above continuously recording turbidimeters produce a 4-20 MA proportional signal that is transmitted to a printer which logs the output on a strip chart calibrated in 0-100 NTU's for incoming raw water and 0-1 NTU for filtered water.

Discrete samples were taken both before and after all the filter vessels and separator units. Samples were collected from both Hach turbidimeters to check the accuracy of the output signal of these units. These discrete samples were collected twice per day. All the discrete samples were analyzed for turbidity on site using a model 2100A turbidimeter, a product of the Hach Chemical Co. Formazin turbidity standards furnished by the Hach Chemical Co. were used to calibrate the 2100A turbidimeter.

TEMPERATURE

The temperature of raw waters from the lake and the finished waters discharged to the clear well were measured and logged once per day. The thermometer was calibrated in centigrade and was certified by the supplier to conform with NBS standards. The thermometer was checked periodically with two or more thermometers also certified by the supplier. A variation of not more than 2% from the average of three or more thermometers was considered acceptable.

COLOR

Color of water samples for this project was analyzed on site with a spectrophotometer model DR2, a product of the Hach Chemical Co. Calibration of the unit for color measurement was accomplished daily prior to analyzing samples using APHA-Platinum Cobalt Standards furnished by the Hach Co.

pH

The pH of the water at all sampling points was analyzed by a Model 16400-00 pH meter, a product of the Hach Chemical Co. The meter was calibrated daily with pH solutions of known values supplied by a chemical supply house.

ALUMINUM

Aluminum concentration following the filtration system but prior to chlorination was analyzed daily as a means of monitoring the chemical feed system. For this purpose the above-mentioned spectrophotometer was used.

This method used proprietary chemicals supplied by the Hach Chemical Co. and was done by the preparation of a calibration curve using solutions with known aluminum concentrations. The solutions spanned a range of 0 through 7 ug at intervals of 0, 1, 3, 5, and 7 ug. Samples or suitable dilutions of samples to conform with this range were used. Standard aluminum solutions supplied by the Hach Co. were used to check the calibration curve before sample analysis. The lower limit of detection of this method is reported to be 0.02 mg/L.

DATA RECORDING

Monthly, this data was assembled by the Project Manager and presented to the Key Investigator. Where necessary, remedial action was taken regarding operation of filtration facility as may be indicated by this data. All process remedial action was documented by the Project Manager and approved by the Key Investigator, prior to implementation. All data was logged daily on a Daily Log Sheet.

OFF-SITE LABORATORY ANALYSIS

The laboratory of the firm of O'Brien and Gere in Syracuse, N.Y. was engaged by the Village of Cayuga to conduct analysis required by this study that was beyond the capability of the on-site laboratory. These analysis were total microscopic count, trihalomenthanes, and the required analysis of NYSDOH Sanitary Code Part 5 for Potable Water Supplies.

Analysis for total microscopic count (TMC) was analyzed from samples collected two times per month of raw water and filtered water prior to the addition of chlorine solution. A graph shown on Figure 5 shows the results of the TMC analysis during the twelve month study period. Water samples to be analyzed for trihalomenthanes were collected from raw water and filtered water prior to addition of chlorine solution. These samples were collected four times during the twelve month period. Once every six months samples were collected for analysis required by NYSDOH Sanitary Code Part 5. This included analysis for nitrate, arsenic, barium, cadmium, chloride, chromium, copper, corrosivity, fluoride, iron, lead, manganese, mercury, selenium, silver, sodium, sulfate, zinc, odor, and alkalinity as CaCO. Results of these analysis are shown on Table 2.

In addition to these, a sample of filtered water was collected weekly and analyzed by the off-site laboratory for aluminum. This was done as a quality check for the on-site laboratory results.

SECTION 7

OPERATING ADJUSTMENTS AND MODIFICATIONS

During the 12 month pilot study it was necessary to make adjustments and a few modifications to optimize the operation of the filtration system and controls.

BACKWASH CONTROL

Quite often during the early weeks of the study the primary filtration portion of the trains, clarifier and mixed media filter, were found to be immediately going into backwash after the backwash cycle was completed. The cause of this was found to be the pressure differential switch. The sensitivity range, or the range at which the switch would open after it had closed due to high pressure differential, was 67% of the differential pressure setting. Since two of the filter trains were in operation while one train backwashes the pressure quite often did not drop sufficiently to open the pressure differential switch. The switch was field adjusted to a set point where the sensitivity is 33% of the differential pressure setting. This stopped the above mentioned problem.

LAKE PUMP CONTROL DURING BACKWASH

In order to backwash the filters, both primary and carbon, it is necessary that the lake suction low lift pump be running. This is necessary for both the clarifier backwash and the filter to waste modes in both the primary and carbon filter trains. As the system reacted to a water level in the distribution system storage tank the high lift pump would shut down when the level was satisfied. Shortly thereafter the clear well would fill and the lake suction pump would shut down. If this occurred during backwashing of the primary filter trains then the clarifier would not be backwashed and the mixed media filter would not be rinsed prior to the service mode.

Since there was sufficient freeboard in the clear well it was decided to install a latching type relay in the lake pump starter coil circuit to bypass the clear well level control. This latching relay would close and latch until the backwash operation in the primary filter trains was complete at which time

the reset signal from the third slave control panel would unlatch the lake pump overide contact.

The carbon filters were backwashed manually and did not require this modification. The operator placed the lake suction pump switch in the hand operation position prior to carbon filter backwash.

BACKWASH RESTRICTORS

The backwash flow from all filter vessels is controlled by orifice type restrictors. The manufacturer installed these devices based on the assumption that the water supply for backwash in all cases had both quantity and pressure in excess of requirements for backwash in each vessel. This was true for the clarifier and the mixed media filters at 90 GPM backwash flow.

The maximum requirement for backwash is for the carbon filter vessels. The design rate was for 150 GPM and the pump utilized for the backwash from the clear well waters was selected to supply 150 GPM at the system's total dynamic head. It was noticed by the operator early in the pilot study that the carbon filter vessel's operating pressure differential after backwashing was gradually elevating. At this point a carbon filter was isolated from the backwash drainage system and the flow during backwash was measured using a stopwatch and a 55 gallon drum. The average flow during backwash was 98 GPM. The orifice restrictor was removed and the flow increased to 148 GPM. Based on this information the flow restrictors were removed from the carbon filters' backwash discharge piping.

This tended to stabilize the pressure differential after backwash and lengthen the cycle period between carbon filter backwashing.

CHEMICAL SOLUTION PROBLEMS

A physical constraint of the access road to the water treatment plant is an old railroad bridge with 9'0" vertical clearance and 8'0" horizontal width. It was necessary to receive chemicals from chemical delivery trucks at a site remote from the water treatment building and then transport these materials in smaller quantities in village vehicles capable of negotiating the old railroad bridge.

Because of this problem a decision was made to purchase alum in a granular form in bags and mix the solution on site at the treatment building. Polymer and hypochlorite solutions were

already liquid and received in 5 gallon containers. The strainers located on the suction piping of the alum solution tank and the hypochlorite solution tank were blinding rapidly and had to be chemically treated to remove the precipitate.

It became necessary to install a water softening system for the solution tank water supply to prevent these problems in the chemical solution systems.

CHEMICALLY CLEANING CARBON FILTER VESSELS

It was anticipated in the design that the carbon media of the carbon filters would accumulate a bio mass. Even though chlorinated clear well waters are used for backwash, the carbon bed adsorbs the chlorine residual and prevents sanitizing the carbon bed. Therefore as mentioned earlier in this report a chemical dosing system was designed to mix sodium hydroxide solutions with incoming waters to each carbon filter during the filter to waste mode of the backwashing cycle. After this dosing was complete then the filter was placed in the beginning of the backwash cycle to flush out the chemically dosed beds. This procedure was carried out at 4 to 5 month intervals.

The rise of total microscopic count and color indicated that the process was not efficiently cleaning the filter beds of the carbon filters. This problem became acute in June and July of 1983. The procedure was then changed in that the sodium hydroxide solution was dosed as stated above until the effluent from each vessel reached a pH of 12 or higher. The system was then shut down for 15 minutes to allow for full impact of the chemical shock on the bio-mass in the filter bed. After this was done the carbon filters were then backwashed. The backwash waters were monitored for both color and turbidity during the filter to waste mode and compared against waters entering the carbon filters. If the waters being discharged by the filters during these tests were not below one unit of color and below 0.2 NTU turbidity then the process was repeated. This process takes about two hours to complete and it is recommended that it be done every three months or as the color concentration in the finished water starts to rise.

This modified carbon filter supplemental cleaning procedure has reversed the trend of a continuing rise of TMC breakthrough as shown on Figure 5 and prevented the TMC concentrations that occurred in June and July of 1983.

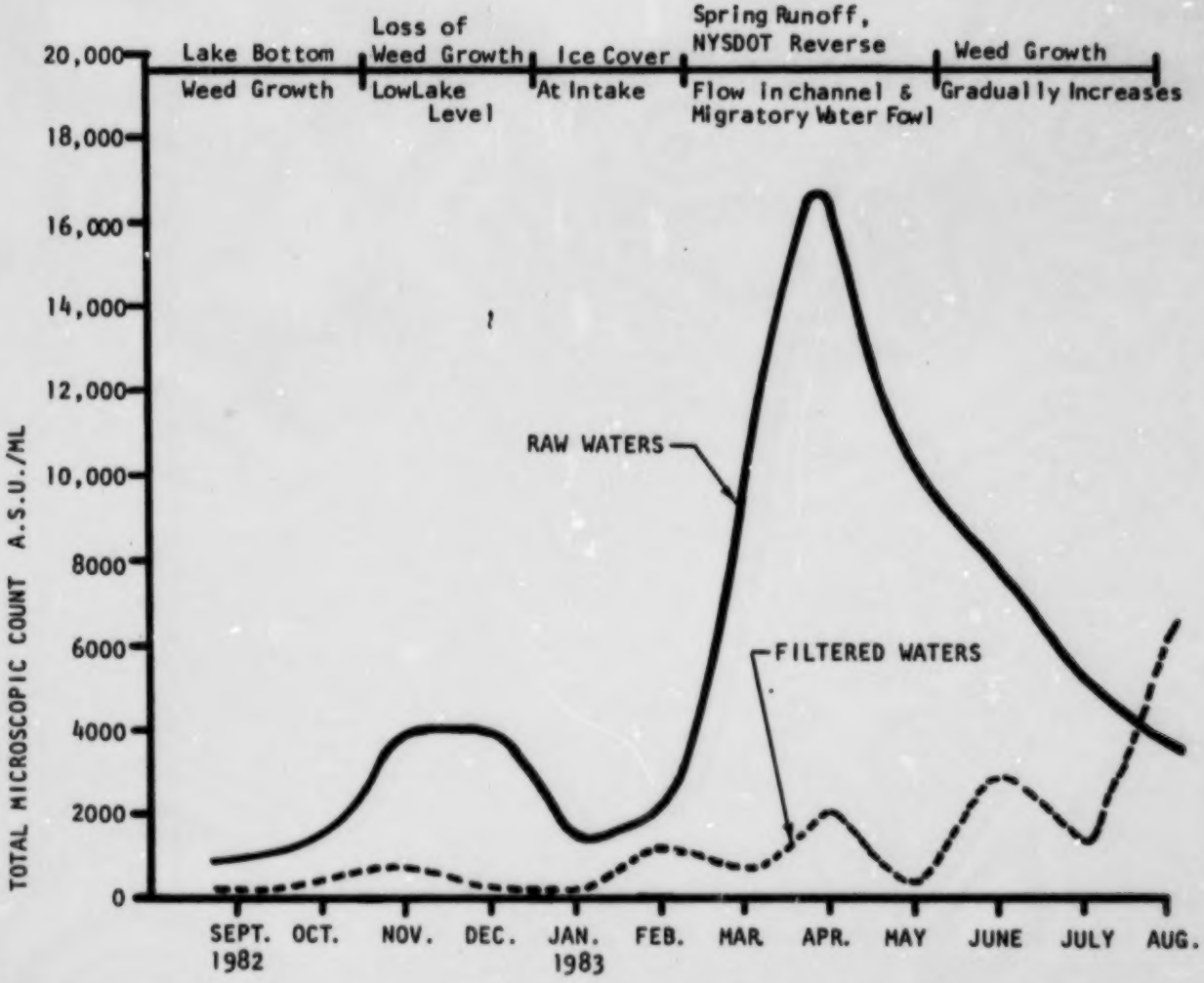


FIGURE 5 AVERAGE MONTHLY RESULTS OF TOTAL MICROSCOPIC COUNT IN BOTH RAW AND FINISHED WATERS

MODIFICATIONS TO LAKE INTAKE STRUCTURE

The original lake intake structure that was installed in 1935 was located in 7.0 feet of water depth during maximum pool level of the lake. During winter months when the lake pool levels are at their minimums the intake, under extreme conditions only, had around six inches of cover. During these periods the structure was subject to ice damage and wave action often caused a loss of prime of the lake pump(s).

During the study period of October and November 1982 the Village of Cayuga relocated the intake structure near the barge canal channel a distance of 110 feet. This caused some high levels of turbidity during the relocation which did not contravene finish water quality. This new location provided a minimum depth of 12 feet of water which will prevent the occurrence of the above mentioned problems of ice damage and loss of prime.

Where taste, odor, and organic contaminants are not a requirement for water treatment then different types of media should be investigated that would eliminate the need for auxiliary chemical cleaning of the carbon or final filters. Periodic monitoring of total microscopic count would seem advisable as a quality check on this cleaning procedure.

SECTION 8

FILTRATION SYSTEM CAPABILITIES

The primary need for a water treatment system at this site was for the removal of turbidity. Other characteristics that required treatment were color, taste, and odor. Following are the results of data collected from this filtration system for twelve consecutive months.

TURBIDITY

The ability of the components of this filtration system to remove turbidity varied from season to season. During the periods of the year when the raw waters have the highest temperatures the clarifier appears to have the best efficiencies. As the raw water temperature drops so does the efficiency of the clarifier and the mixed media filter and carbon filter efficiencies increase. The efficiency of the system remains relatively constant. The graph shown on Figure 2 depicts the turbidity removal capabilities through the system.

NYSDOH requirements for filter effluent based on Table A regarding turbidity removal are 95% of samples analyzed to be equal to or less than 0.50 NTU, 75% of samples analyzed to be equal to or less than 0.30 NTU, 50% of samples analyzed to be equal to or less than 0.20 NTU.

The graph shown on Figure 6 shows that this system was able to conform with the turbidity criteria of "Table A" at this site.

The ability of this filtration system to react to varying raw water turbidities is shown on Figure 7 and Figure 8. The least efficient period occurred when the raw water turbidity hovered at the chemical feed system increasing set point from about 32 to 33 hours as shown on Figure 8. The maximum turbidity during this erratic period was 0.8 NTU.

COLOR

The finished water color never exceeded 3.2 units which was well within the "Table A" requirements of 5 units. The raw water color concentrations varied from monthly averages of slightly

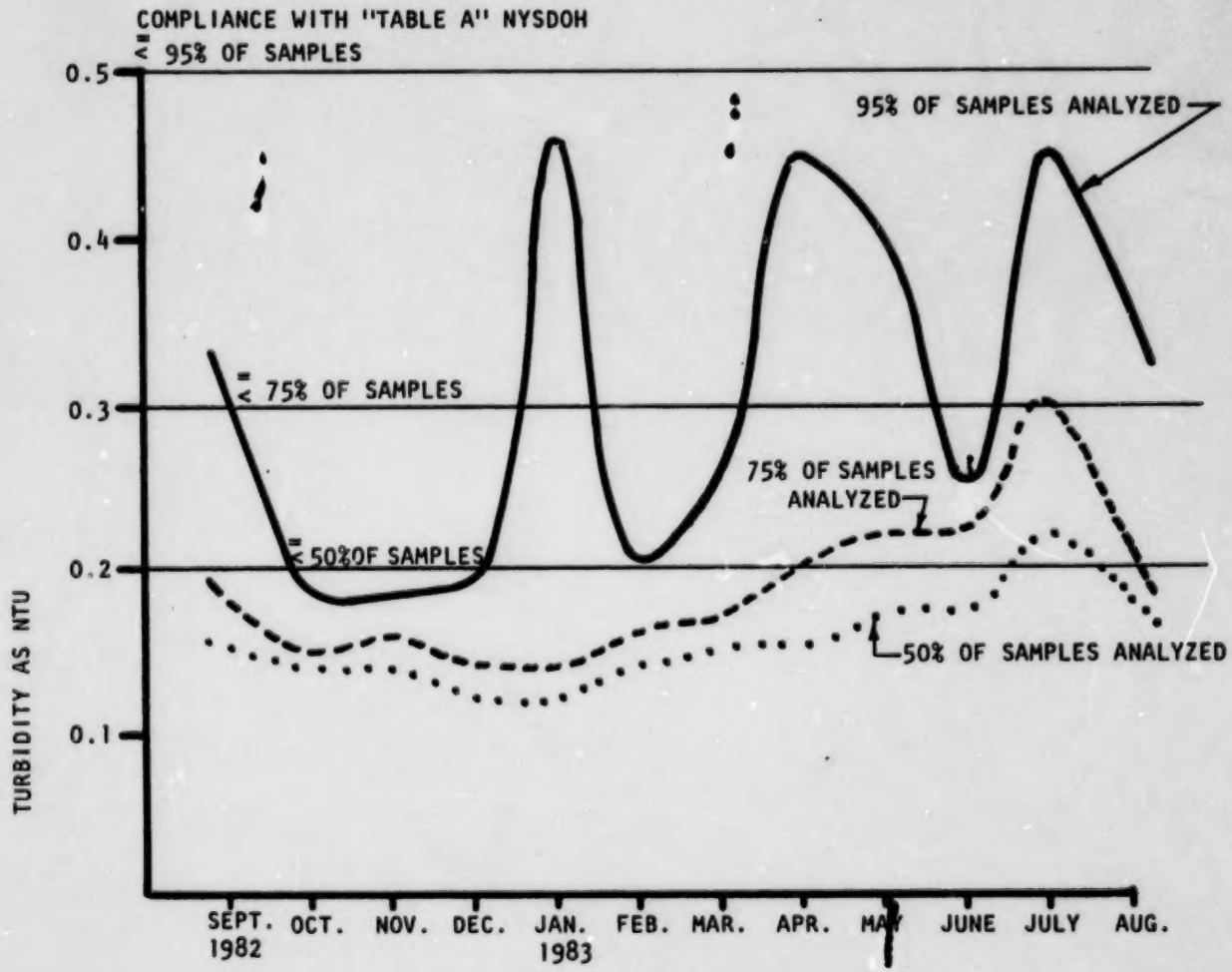


FIGURE 6 COMPLIANCE OF FINISHED WATER WITH TURBIDITY REMOVAL CRITERIA OF NYSDOH "TABLE A" BASED ON MONTHLY AVERAGES

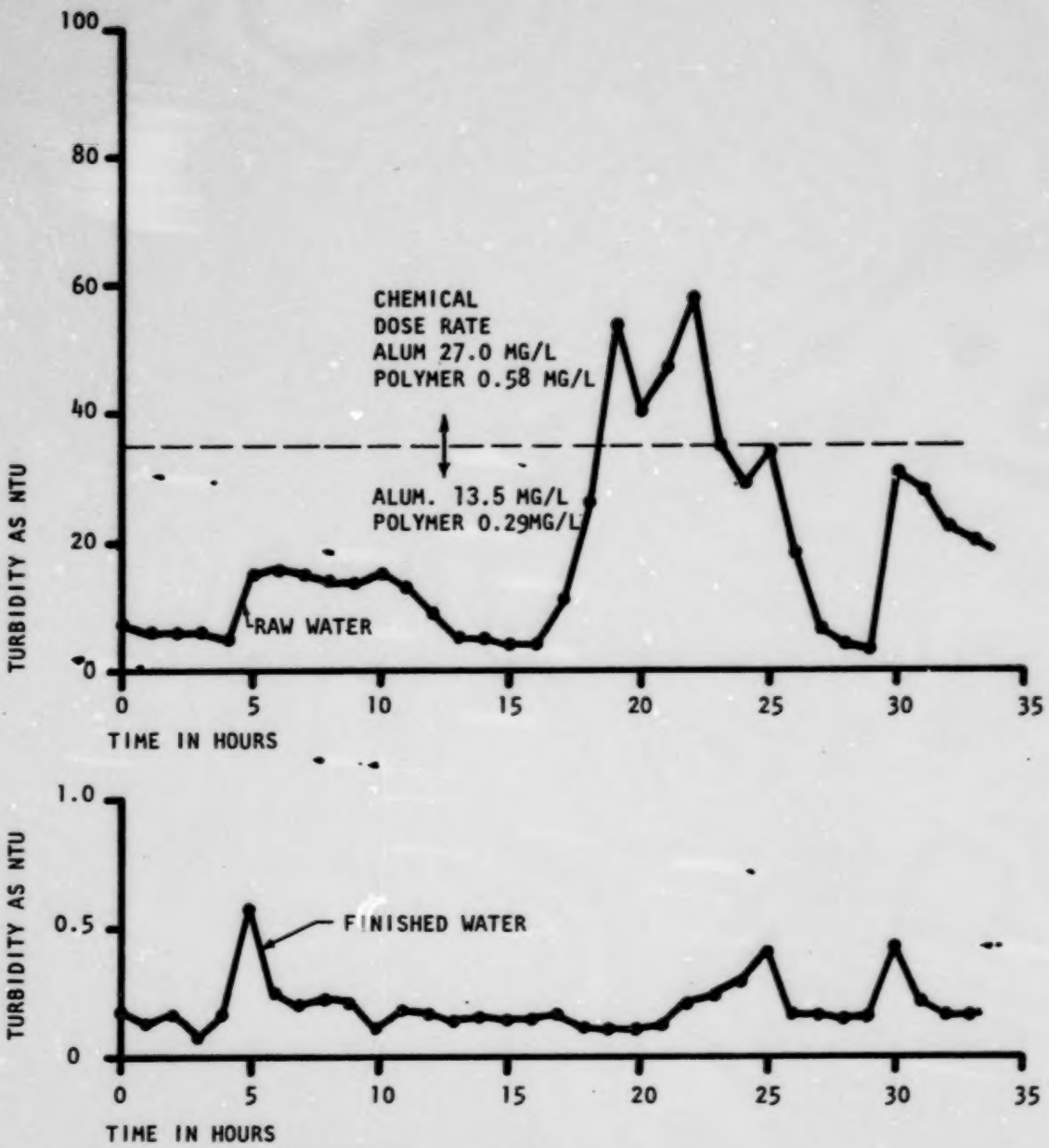


FIGURE 7 FILTRATION SYSTEM REACTIONS TO EXTREME RAW WATER TURBIDITY VARIATIONS. START AT 8 P.M. MARCH 26, 1983.

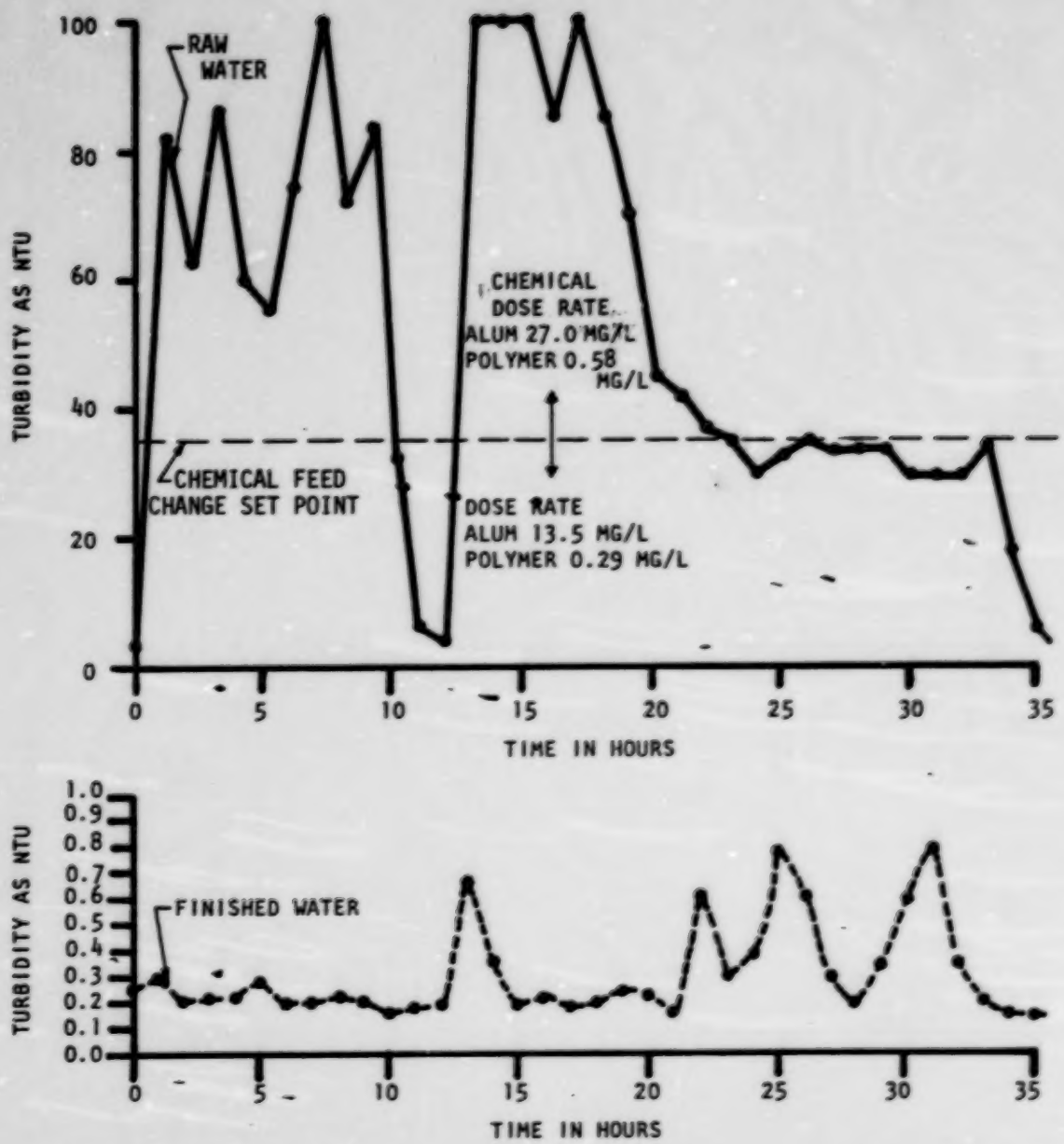


FIGURE 8 FILTRATION SYSTEM REACTION TO EXTREME RAW WATER TURBIDITY VARIATIONS. START AT 8:00 AM APRIL 14, 1983.

over 5 units to almost 15 units. The highest color concentrations occurred during March and April during spring run-off and the annual visitation of migratory waterfowl in the north end of Cayuga lake.

A graph showing average monthly color concentrations in both raw lake waters and finished waters is shown on Figure 9.

TASTE AND ODOR

The fact that the people of Cayuga have commented on the quality of the water greatly improving, particularly regarding drinking and for culinary purposes, is testimony to the system's ability to remove taste and odor.

ALUMINUM

As mentioned earlier in this report, the breakthrough of aluminum in the finished water was directly related to coagulation pH. As the pH of the raw waters elevated above 7.4 the concentrations of aluminum in the finished water would be at .15 mg/L or above. Figure 10 shows the relationship of raw water pH and aluminum concentration in the finished water.

TRIHALOMETHANES

The offsite laboratory analyzed water samples for trihalomenthanes. The analysis was conducted for chloroform ($CHCl_3$), Bromodicloromethane ($BrCl_2CH$), chlorodibromomethane ($ClBr_2CH$), and Bromoform ($CHBr_3$). The analysis was conducted four times during the study period on both raw waters and on filtered waters. Samples were analyzed as both instantaneous and terminal. In the case of instantaneous (Inst) the sample was treated with Sodium Thiosulfate and analyzed. The terminal (Ter) analysis required that the sample be dosed with chorine and stored for seven days. At the end of the storage period the sample was dechlorinated with thiosulfate and analyzed. The results of these analysis are shown on Table 4.

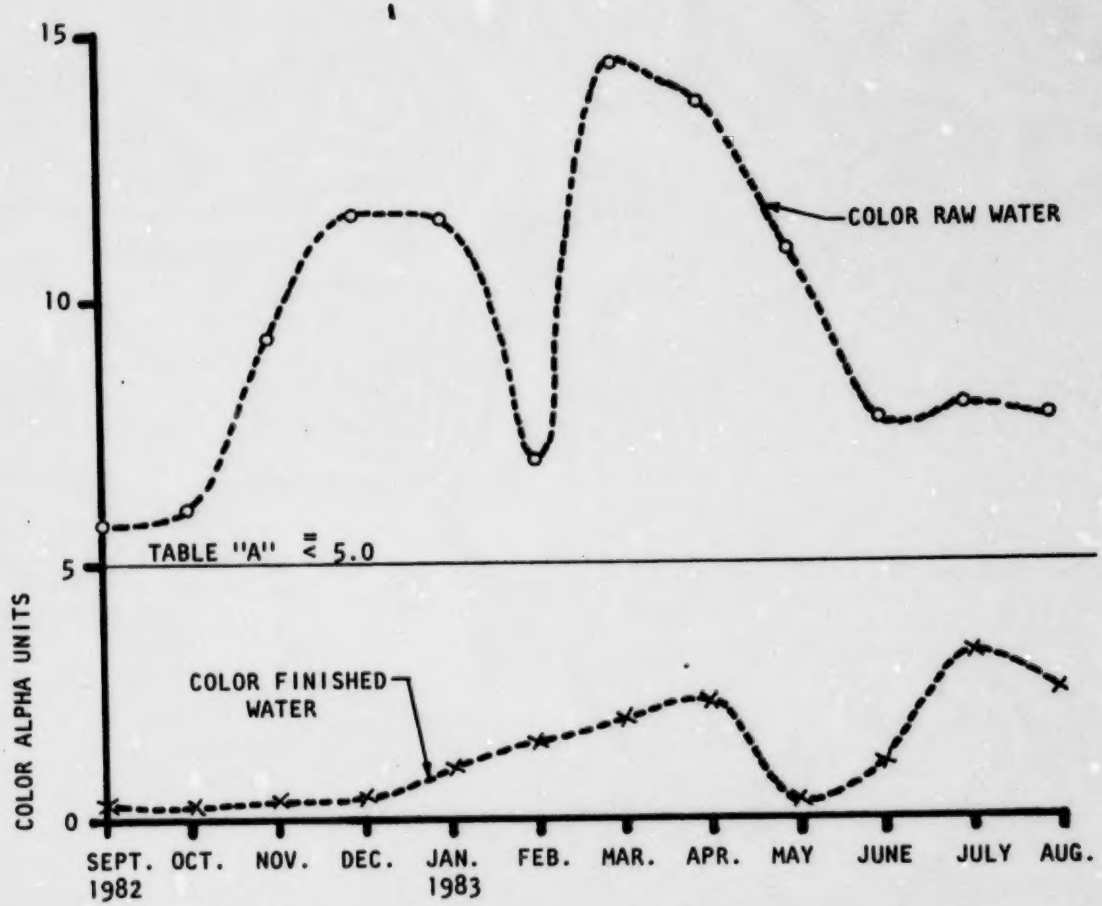


FIGURE 9 COLOR REMOVAL CAPABILITIES OF FILTRATION SYSTEM AND COMPLIANCE WITH COLOR CRITERIA OF NYSDOH "Table A"

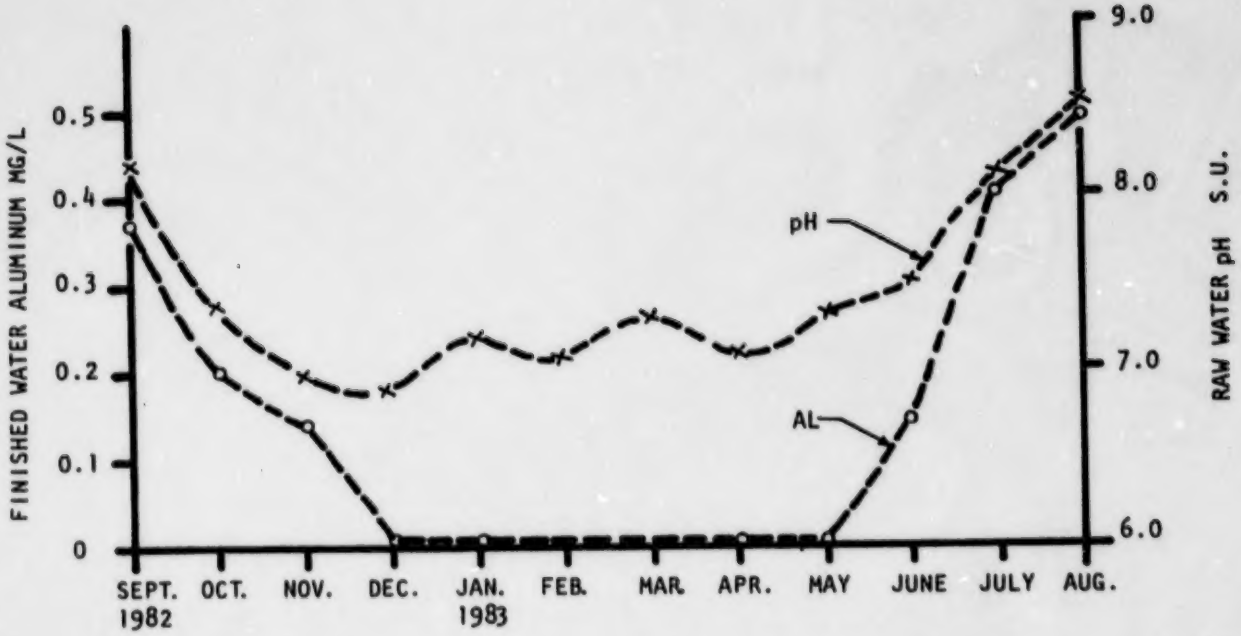


FIGURE 10 EFFECT OF COAGULATION pH ON THE ALUMINUM CONCENTRATION IN FINISHED WATER

TABLE 4

TRIHALOMETHANE ANALYSIS RESULTS

SAMPLE SOURCE	SUBSTANCE µg/L							
	$CHCl_3$		$BrCl_2CH$		$ClBr_2CH$		$CHBr_3$	
	Inst.	Ter.	Inst.	Ter.	Inst.	Ter.	Inst.	Ter.
RAW WATER								
A.) Maximum	1.0	200.0	1.0	60.0	1.0	8.0	1.0	1.0
B.) Minimum	1.0	190.0	1.0	44.0	1.0	24.0	1.0	5.0
FILTERED WATER								
A.) Maximum	1.0	100.0	1.0	26.0	1.0	36.0	1.0	21.0
B.) Minimum	1.0	38.0	1.0	15.0	1.0	14.0	1.0	1.0

All of the above samples were collected at the study site prior to the addition of chlorine solutions.

The samples that were chlorinated and held for seven days for the terminal analysis were dosed with a chlorine solution until the sample stabilized at a 20 mg/L free chlorine residual. Samples that were collected from the filtered and chlorinated waters at Cayuga during the earlier small scale Pilot Study in 1981 were analyzed for instantaneous trihalomethanes and were found to have maximum concentrations of not more than 6.0 ug/L.

The higher terminal concentrations may well be the result of high laboratory chlorine residuals as these residuals are up to twenty times more than normal clear well chlorine residuals of 1 mg/L in the filtered water. Currently, communities of less than 10,000 population are not required to conform to maximum trihalomethane concentrations in public water supplies. By January 1, 1986 all public water supplies in New York State must comply with the maximum level of combined trihalomenthanes of 100 µg/L based on NYSDOH regulations. Continued monitoring of trihalomenthanes in the Village of Cayuga's water supply is recommended to evaluate future requirements.

TOTAL MICROSCOPIC COUNT

A total of 24 samples for total microscopic count were collected, both of the raw water and the finished water during this pilot study period. These samples were collected at the rate of two per month. The graph shown on Figure 5 shows the average monthly total microscopic results as areal standard units per ML (A.S.U./ML). The trend rise in the finished water from February 1983 thru August 1983, in the opinion of the author, was caused by early failures to properly backwash and/or properly cleanse the carbon filter bed. After the backwash restrictors were removed and the final method developed for the chemical cleaning process using caustic soda solution, which is discussed in the section entitled "Chemically Cleaning Carbon Filter Vessels" of this report, there was a substantial drop in color and TMC after the end of the pilot study period. The graph shown on Figure 11 indicates the TMC results as compared to NYSDOH "Table A" criteria.

pH EFFECT ON COAGULATION

The pH of the untreated lake waters varied from lows of 6.4 to highs of 8.8. The breakthrough of aluminum in the finished water when the lake waters were at pH 7.2 and above resulted in aluminum concentrations in excess of NYSDOH Guidelines of 0.15 mg/L or less. The effect of coagulation pH on aluminum breakthrough in the filtered water has been well documented by others but nevertheless an attempt was made to enhance the capture of aluminum in the filter by varying chemical dose rates. The dose rate of the alum was reduced to various levels. In each case the polymer dose was increased at the rate of 1 part polymer per 10 parts of alum decreased. This procedure did not reduce the aluminum breakthrough in the finish water and caused a rise in the turbidity breakthrough proportionate to the alum reduction.

The alum dose rate was then returned to its original rate and the polymer rate was advanced in an attempt to prevent the aluminum breakthrough. This procedure simply limited the filter run between backwashing by blinding the primary filter train. The chemical feed rates were returned to 13.5 mg/L as alum and 0.29 mg/L as polymer which produced the highest quality water.

It is felt that the best method of preventing aluminum breakthrough at concentrations at or above 0.15 mg/L would be to chemically adjust the pH of the raw waters prior to the addition of alum and polymer.

A graph showing the impact of coagulation pH on aluminum concentration in filtered water is shown on Figure 10.

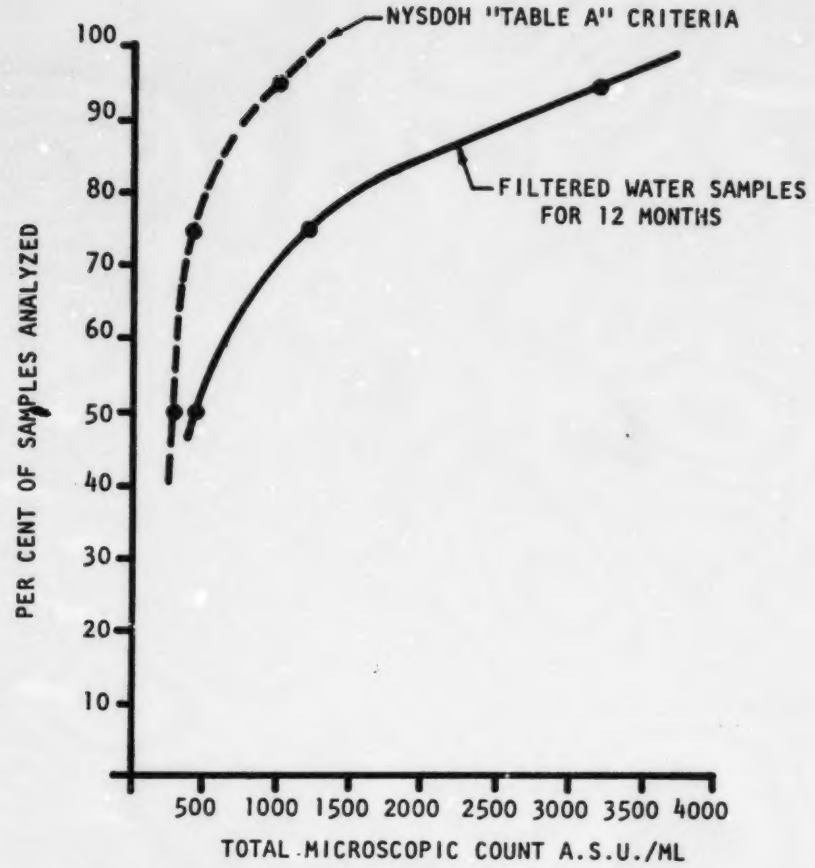


FIGURE 11 TOTAL MICROSCOPIC COUNT AS AREAL STANDARD UNITS/ML. COMPARISON OF FINISHED WATER RESULTS WITH NYSDOH "Table A" CRITERIA.

COAGULATION pH AND TEMPERATURE EFFECT ON TOTAL MICROSCOPIC COUNT CONCENTRATIONS

There is a relationship between temperature and pH of the raw waters at this study site. A graph showing the relationship is shown in Figure 12. It is assumed that the raw water temperature is the controlling factor resulting in changes of the biological activity that occurs in the lake waters that affect pH levels.

The total microscopic count of particles in the finished water generally elevated as the raw water temperature declined. This trend is shown on Figure 13. Raw water pH has little or no effect on the TMC concentrations in the raw water but has a significant impact on TMC concentrations in the finished water. This is graphically shown in Figure 14. The highest concentrations of TMC in the raw water occurred when pH was between 7 and 8 but did not coincide with any pattern of climatological events or conditions.

PRESSURE LOSSES THROUGH THE FILTER VESSELS

Flow as gallons per minute or pressure loss as psi per filter train, or vessel, differed depending on how long after backwash the gages were read and logged. The flows varied from 49 GPM to 43 GPM with 45 GPM being the average flow through the vessels. This represents an average filtration rate of 6.4 GPM/ft^2 in the contact clarifier and the mixed media filter and 4.7 GPM/ft^2 in the carbon filters. Table 5 tabulates the pressure losses through the system, expressed as psi and feet of water.

TABLE 5. PRESSURE LOSSES THROUGH THE FILTER VESSELS

Component	Average psi	Average ft.	Maximum psi	Maximum ft.	Minimum psi	Minimum ft.
Cyclone Separator*	9	20.8	9	20.8	9	20.8
Contact Clarifier	5	11.6	9	20.8	2	4.6
Mixed Media Filter	3	6.9	6	13.9	2	4.6
Carbon Filter	10	23.1	15	34.7	7	16.2
TOTALS	27	62.4	39	90.2	20	46.2

*Estimated

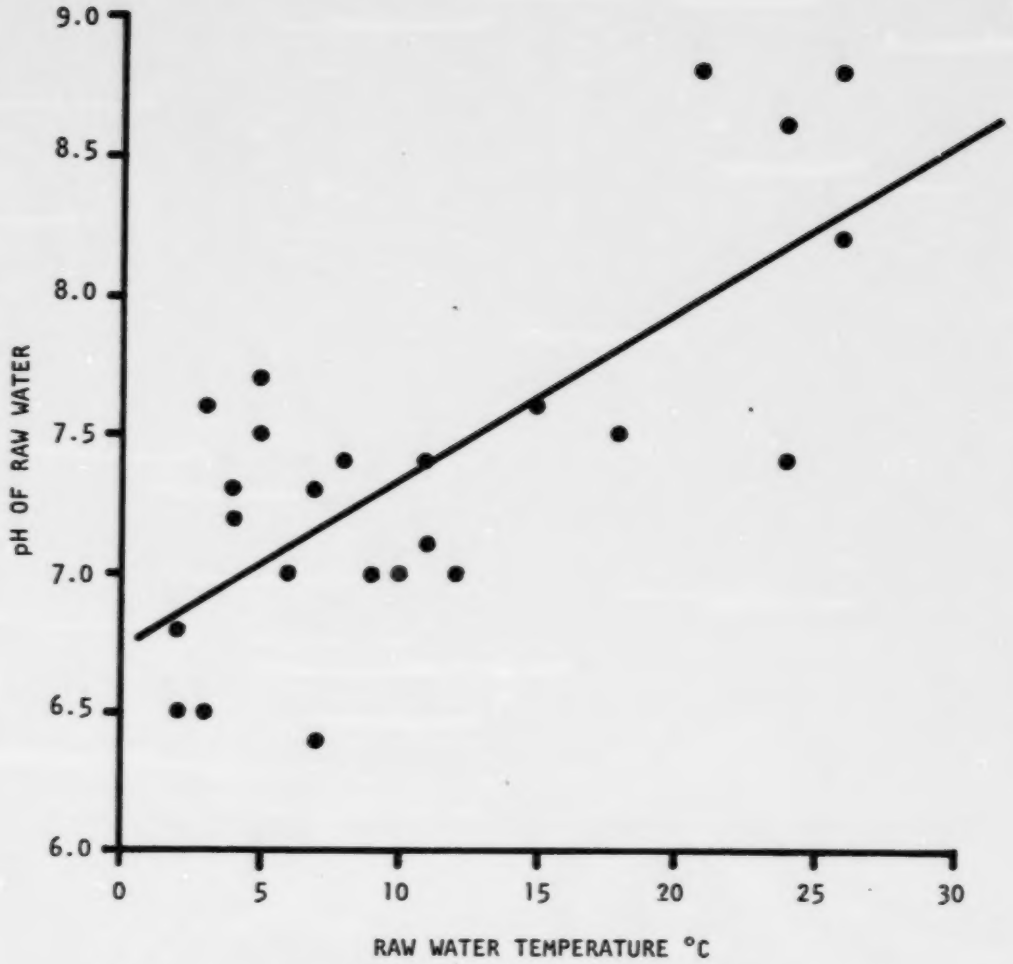


FIGURE 12 RELATIONSHIP OF RAW WATER pH AND RAW WATER TEMP. °C

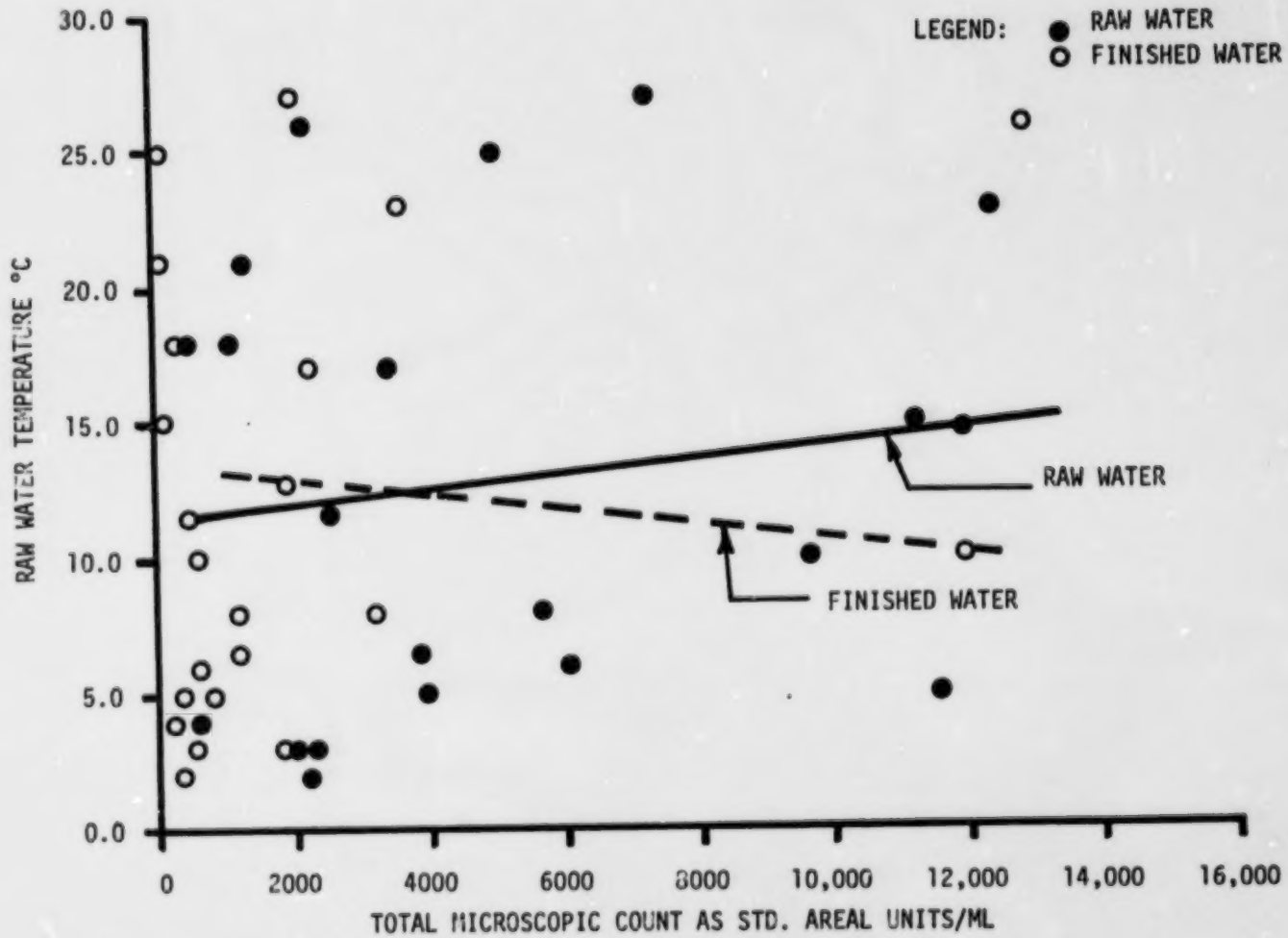


FIGURE 13 RELATIONSHIP OF RAW WATER TEMPERATURE TO TMC CONCENTRATIONS

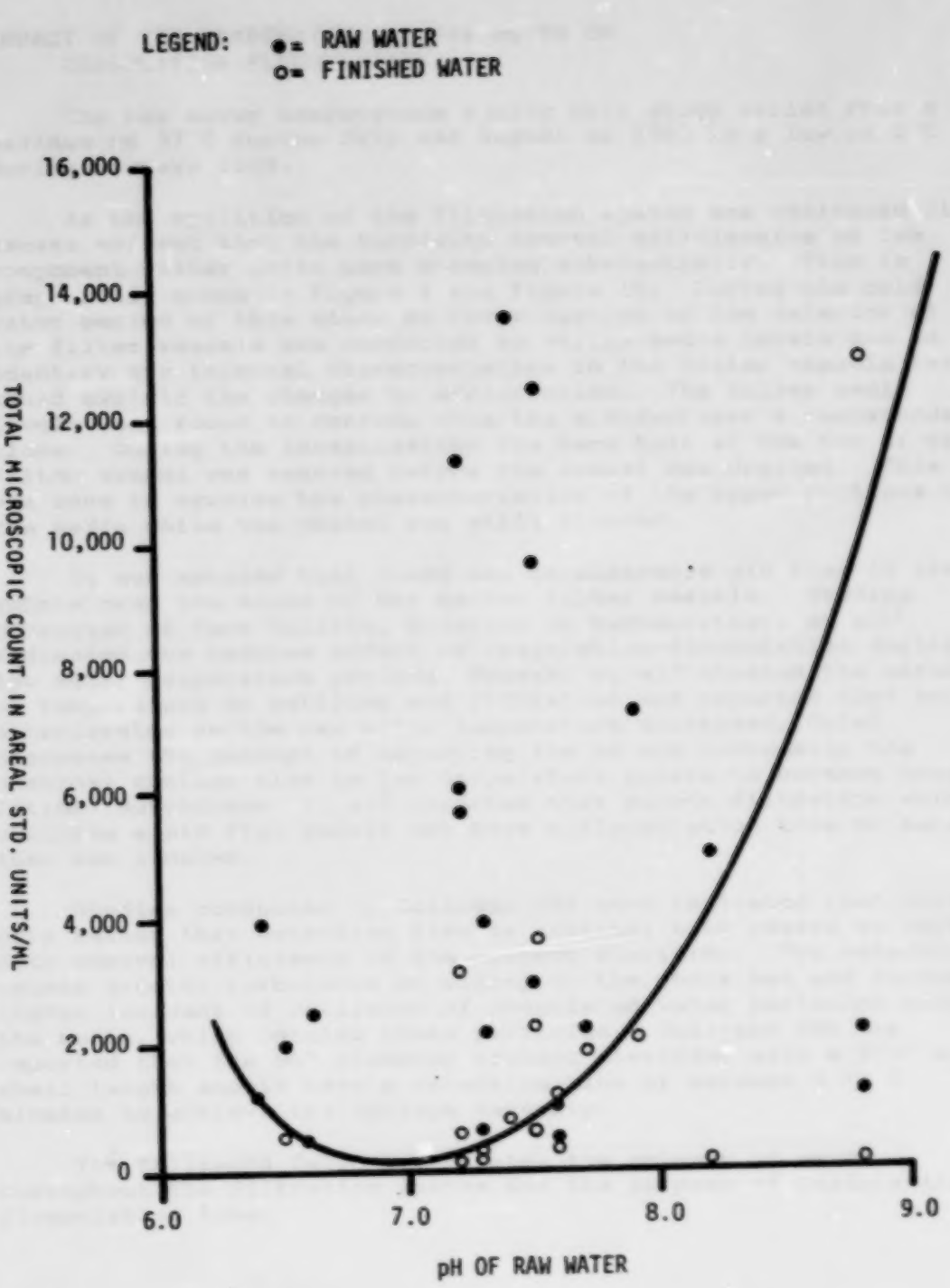


FIGURE 14 MOST PROBABLE BREAKTHROUGH OF MICROSCOPIC PARTICLES BASED ON COAGULATION pH

IMPACT OF THE TEMPERATURE OF RAW WATER ON COAGULATION-FLOCCULATION

The raw water temperature during this study varied from a maximum of 27°C during July and August of 1983 to a low of 2°C during January 1983.

As the operation of the filtration system was monitored it became evident that the turbidity removal efficiencies of the component filter units were changing substantially. This is graphically shown in Figure 2 and Figure 15. During the cold water period of this study an investigation of the interior of the filter vessels was conducted to verify media levels and to identify any internal characteristics in the filter vessels that would explain the changes in efficiencies. The filter media levels were found to conform with the manufacturer's recommendations. During the investigation the hand hole at the top of each filter vessel was removed before the vessel was drained. This was done to examine the characteristics of the upper portions of the media while the vessel was still flooded.

It was noticed that there was considerable pin floc in the waters over the media of the carbon filter vessels. Studies conducted at Fort Collins, Colorado by Kuchenrither, et al[11] indicated the reduced effect of coagulation-flocculation during low water temperature periods. Hannah, et al[4] studied the effects of temperature on settling and filtration and reported that both deteriorated as the raw water temperature decreased. Cole[3] discusses the concept of adjusting the pH and increasing the chemical contact time in low temperature waters to enhance coagulation. Hutchinson, et al[2] reported that direct filtration which utilizes a pin floc should not have a flocculation time of more than ten minutes.

Studies conducted by Culligan USA have indicated that velocity rather than detention time is critical with regard to turbidity removal efficiency of the contact clarifier. The velocity causes greater turbulence or mixing in the media bed and forces a higher incident of collision of coagulated water particles with the media, which retains these particles. Culligan USA has reported that the 36" diameter contact clarifier with a 5'0" side shell length should have a retention time of between 3 to 5 minutes to achieve the optimum velocity.

The following Table 6 tabulates the volumes of water throughout the filtration system for the purpose of calculating flocculation time.

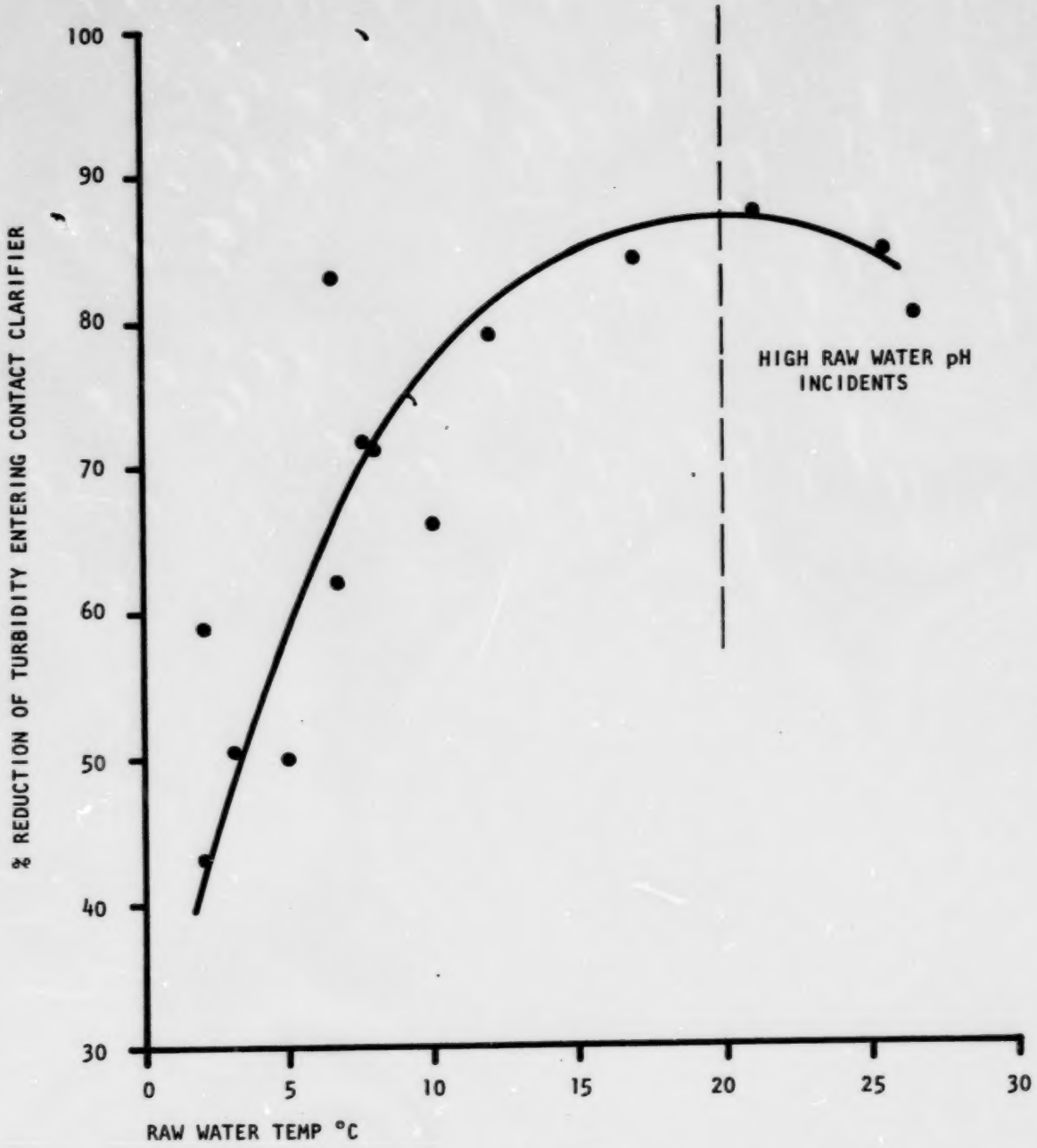


FIGURE 15 CONTACT CLARIFIER EFFICIENCY COMPARED TO RAW WATER TEMPERATURE.

TABLE 6. HYDRAULIC VOLUME OF FILTRATION SYSTEM

	Filter System Component		Volume in Gallons
1.	Piping from point of coagulation chemical injection to point of filtration train branch from raw water manifold. (Average)		2.2
2.	Piping including filter vessel harness and connections.		2.0
3.	Contact clarifier	A.) Above media bed	85.0
		B.) Throughout media bed	78.0
4.	Mixed media filter	A.) Above media bed	68.0
		B.) Throughout media bed	63.6
5.	Piping manifold between mixed media filters and carbon filters. (Average)		3.7
6.	Carbon Filters	A.) Above media bed	156.0
		B.) Througout media bed	91.0
			549.5 G

The average flow per filter train during the cold water period was 45 GPM. Since the carbon filters were capturing turbidity sufficient to satisfy NYSDOH guidelines, then it is necessary to delete the hydraulic volume of the carbon filter bed or 91 gallons. This leaves a total of 458.5 gallons or 10.2 minutes detention or flocculation time prior to the last filter bed to react to after-floc caused by the cold water in this system. When the raw water temperature is at or above 10°C the turbidity leading to the carbon filters is at the lowest point. This would represent the volumes set forth in Items 1, 2, 3, 4A in Table 5 or 235 gallons. This volume represents a flocculation time of 5.2 minutes prior to entering the mixed media filter bed. It would appear the 5 minutes flocculation time prior to the waters entering the mixed media filter bed is sufficient for raw water supplies that do not drop below 10°C. When the raw water temperatures drop to near 0°C then consideration should be given to allowing 10 minutes flocculation time prior to the mixed media filter bed. The latter would reduce loadings to the carbon filter and allow it to function as a polishing filter year-round.

TURBIDITY REMOVAL

The impact of coagulation pH on turbidity removal was less and at no time did the high pH of the lake waters cause a contravention of "Table A" guidelines for turbidity. A graph showing the relationship of coagulation pH and finished turbidity is shown on Figure 16.

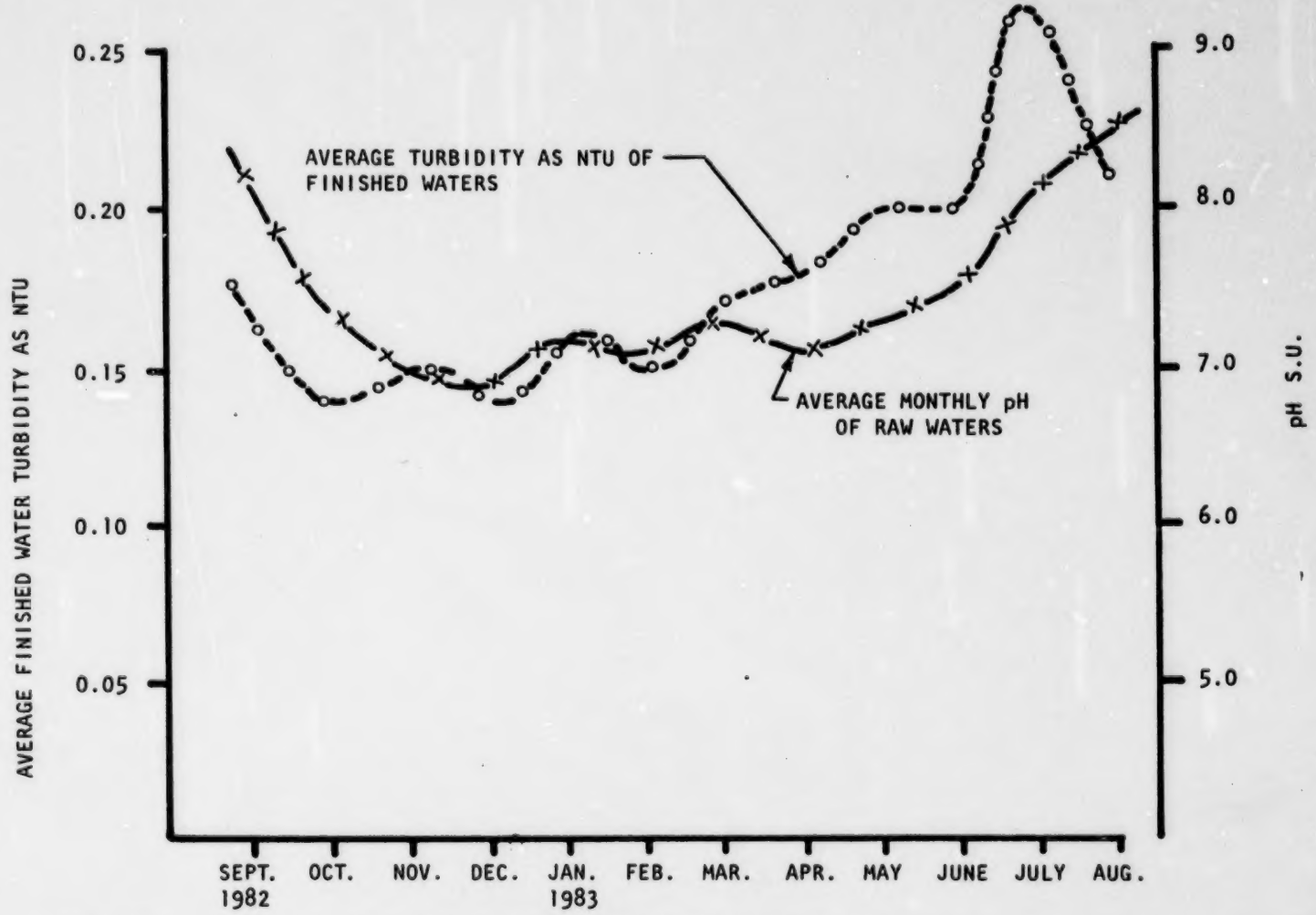


FIGURE 16 EFFECT OF COAGULATION pH ON FINISHED WATER TURBIDITY

SECTION 9

INSTALLATION AND OPERATING COSTS

SYSTEM INSTALLATION COSTS

Following on Table 7 are the equipment and installation costs for this filtration system;

TABLE 7. EQUIPMENT AND INSTALLATION COSTS

Description	Cost in Thousands of Dollars (1982)
1.) Filtration equipment including vessels, media, diaphragm control valves, chemical solution pumps and tanks, vessel harnesses, and electrical control panels.	$155
2.) Filtration system piping including valves, orifice meters, gages, and sludge handling piping from backwash treatment system.	$41
3.) Lake suction pumps and clearwell backwash pump.	$5
4.) Existing structure retrofit to receive filtration system and sludge handling from backwash treatment system.	$20
5.) Electrical including new service, distribution and control wiring.	$26
6.) Retrofit lake intake piping system	$18
7.) Painting	$3
TOTAL COST	$268

This system is capable of delivering 216,000 GPD as treated water. This installation represents a cost of $1.24 per daily design gallon of water produced. This figure is substantially below the average cost for systems of this magnitude installed in new structures. This cost is site specific and requires careful study to identify it for comparison of treatment installation costs.

OPERATING LABOR INPUT

The labor input for operation of this pilot study was divided into four categories as follows:

System Inspection: Visual observations were made of all gages for pressure and flow determinations and a daily log was kept of the same. To observe general operating conditions and review monitoring results for possible remedial actions or adjustments and to log such activity. Time devoted to transporting chemicals and mixing chemical solutions is included in this item also. Average daily time for this item was 1.0 hour.

System Adjustments: Time devoted to remedial or normal adjustments of flow rates, chemical feed rate, or sludge removal from backwash treatment system. Average daily time for this item was 0.31 hour.

Sample Analysis: Time devoted to collecting samples and analyzing all parameters required by the onsite laboratory facilities. This includes all standardization and calibration procedures. Average daily time for this item was 1.28 hours.

Repair and Maintenance: Time devoted to repair, painting, or rehabilitation of system components. This item also included such tasks as lubrication, cleaning, and other primary maintenance activities. Average daily time for this item was 0.13 hour.

This represents operational and maintenance labor input at the rate of 2.72 hours per day, or 0.022 hours per 1000 gallons of treated water supplied to the distribution system.

POWER COSTS

Power consumption required to operate the lake pumps, chemical pumps, chemical mixers, backwash pump, and controls for this pilot study filtration system was 73,315 Kw Hr. During the pilot study period of 12 months 44,784,000 gallons of treated water was delivered to the Village of Cayuga's potable water distribution system. This data converts to 1.64 KwHr. per 1000 gallons

treated water produced. At the local cost of $0.062 per KwHr. this represents a cost of $4,545.53 per year, or $0.102 per 1000 gallons of water. In addition to this a cost of $0.11 per 1000 gallon was incurred by high lift pumps injecting these waters into the distribution system.

CHEMICAL COSTS

Chemicals used for this pilot study during the twelve month period were 4727 lb. of aluminum sulfate (Alum), 49 liters of F-86 polymer, 725 gallons of sodium hypochlorite, and 10 gallons of 50% sodium hydroxide. The following table relates the cost of these chemicals at this site.

Chemical	Quantity Used	Cost Per Year	Cost Per 1000 Gallons Water
Alum	4727 lbs.	$ 898.13	$ 0.02
Polymer	49.0 liters	145.53	0.003
Hypochlorite	725 gallons	1,123.75	0.025
Sodium Hydroxide	10 gallons	36.00	0.0008
Total Cost		$2,204.41	$ 0.0488

The combined costs of power and chemicals during this study were $6,749.94 or $0.1508 per 1000 G of water produced. This does not include high lift pumping costs.

SLUDGE REMOVAL COSTS

Sludge from the backwash water settling tank was removed at the rate of once every six months. This is done by drawing sludge off through a system of piping by gravity and discharging the sludge to a septic tank scavenger tank truck. The sludge is then transferred to an approved land fill site for disposal.

About 6000 gallons as sludge are removed or 12000 gallons sludge per year at a cost of $640. This calculates to $0.014 per 1000 gallons of water produced.

COST ESTIMATES FOR ALTERNATE SYSTEMS

Based on data submitted by Gumelman, et al[12] the estimated cost of installing alternate water treatment equipment as compared with the pressure filtration system installed at this site as shown in Table 8. These estimates do not take into consideration the suitability of existing structures to receive the various equipment upon which the costs are based.

TABLE 8: COST ESTIMATES FOR 150 GPM TREATMENT SYSTEMS BASED ON 1983 DOLLARS

Type of System		Estimated Cost
1. Culligan Multi-tech Filtration & GAC		$220,000
2. Conventional Package Plant		$243,000
Plant	$180,000	
Pressure GAC	55,000	
Hypochlorinator	8,000	
3. Neptune Trident System		$250,000
Plant	$178,000	
Pressure GAC	55,000	
Pump	9,000	
Hypochlorinator	8,000	
4. Package Gravity Filter		$272,000
Chemical Feed	$ 7,000	
Floc-Clarifier	110,000	
Filter	83,000	
Pressure GAC	55,000	
Pump	9,000	
Hypochlorinator	8,000	
5. Covered Slow Sand Filter		$522,000
Filter	$450,000	
Pressure GAC	55,000	
Pump	9,000	
Hypochlorinator	8,000	

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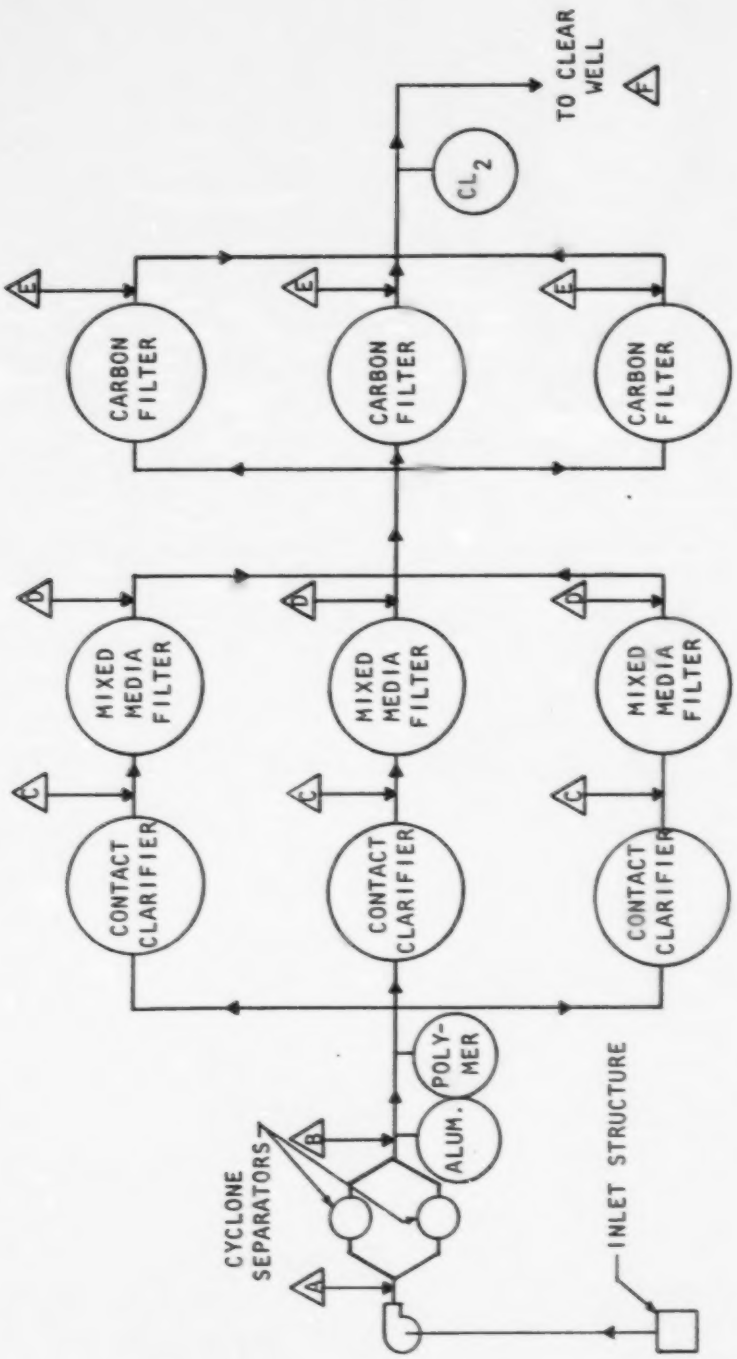
APPENDICES

Following are specific pages taken from quarterly reports that were prepared during the demonstration project period of September 1, 1982 through August 31, 1983.

APPENDIX A FIGURE 1 STUDY PRESSURE FILTRATION SYSTEM SCHEMATIC



△ DENOTES SAMPLING POINTS

FIGURE 1 PILOT STUDY PRESSURE FILTRATION SYSTEM SCHEMATIC

APPENDIX B TURBIDITY ANALYSIS RESULTS

TURBIDITY AS NTU

SEPT. 1982	TIME	B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
1	1130	1.5	.41	.40	.41	.27	.26	.50	.19	.19	.21	.18
1	1430	2.2										.16
2	0930	2.4										.16
2	1500	2.2	.50	.45	.42	.50	.27	.38	.19	.25	.20	.18
3	1008	2.0	.45	.43	.38	.45	.41	.35	.18	.21	.17	.16
3	1700	3.4										.16
4	0900	2.8										.22
4	1415	5.0										.14
5	1030	2.6										.16
5	1900	2.8										.17
6	1000	3.2										.25
6	1730	2.8										.30
7	1200	2.4										.16
7	1515	2.8	.48	.44	.42	.33	.29	.31	.19	.19	.17	.17
8	0945	1.8	.42	.38	.31	.29	.28	.27	.19	.17	.17	.15
8	1615	2.5										.14
9	1023	2.2										.30
9	1400	3.2	.56	.48	.48	.41	.29	.30	.21	.19	.18	.18
10	1300	2.8										.25
10	1500	2.6	.95	.89	.73	.66	.65	.65	.50	.35		.35
11	0940	2.3										.40
12	1030	4.0										.40
13	1045	2.4										.25
13	1430	3.8	1.1	1.0	1.0	.72	.68	.65	.36	.33	.35	.30
14	1030	2.6	.42	.36	.35	.29	.25	.35	.20	.18	.30	.15
15	0945	2.0										.12
15	1445	4.5	.32	.31	.35	.22	.19	.20	.16	.19	.14	.11
16	1030	2.2										.11
16	1400	2.8	.45	.19	.40	.24	.21	.25	.19	.16	.18	.17
17	0751	2.6										.09
17	1145	2.4	.40	.35	.38	.20	.19	.23	.14	.12	.15	.11
18	1000	3.2										.17
18	1830	2.2										.11
19	1015	2.4										.12
20	1100	3.5	.32	.35	.31	.22	.18	.20	.15	.16	.15	.15
20	1600	3.0										.12
21	0848	1.8										.11
21	1250	2.4	.48	.32	.55	.35	.23	.25	.16	.18	.17	.15
22	0700	2.4										.11
22	1030	3.0	.31	.27	.25	.17	.15	.16	.12	.16	.13	.12
23	0930	1.8										.11
23	1100	2.5	.38	.40	.28	.22	.21	.19	.15	.16	.19	.13
24	1000	2.4	.45	.22	.40	.45	.23	.38	.19	.18	.22	.19
25	1205	2.8										.11
25	1600	2.8										.11
26	1555	3.5										.12
26	1900	3.2										.11
27	1016	3.8	.62	.40	.32	.18	.15	.18	.14	.13	.14	.13
28	1200	2.2										.11
28	1600	1.8	.40	.38	.32	.28	.26	.27	.18	.16	.15	.12
29	0700	1.8										.11
29	0836	2.4	.46	.30	.32	.31	.22	.26	.16	.16	.17	.15
30	1325	1.75	1.0	.70	.50	.31	.26	.44	.26	.27	.34	.15
AVE		2.67	.52	.44	.42	.34	.28	.32	.20	.19	.19	.17

TURBIDITY DATA	RAW WATER	FINISHED WATER	PERCENT REDUCTION
MAX NTU	5.00	0.40	97
AVE NTU	2.67	0.17	94
MIN NTU	1.50	0.09	83

APPENDIX B TURBIDITY ANALYSIS RESULTS

OCT 1982	TIME	TURBIDITY AS NTU B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
1	1400	2.0										.11
1	1540	2.2	.26	.28	.28	.18	.17	.23	.15	.15	.15	.17
2	1045	3.2										.15
2	1615	4.8										.12
3	1024	2.8										.14
3	1630	4.0										.13
4	0915	3.8	.82	.80	.70	.17	.14	.17	.13	.11	.13	.13
4		3.8										.14
5	1020	3.8	.35	.30	.28	.22	.18	.20	-	.15	.19	.25
5	1615	3.0										.16
6	1044	3.0	.44	.41	.33	.19	.15	.19	.13	.14	.13	.13
6		3.0										.24
7	1035	2.2	.40	.33	.31	.22	.18	.17	.15	.16	.19	.16
7	1945	3.0										.15
8	0805	3.5	.42	.40	.38	.20	.21	.23	.19	.17	.18	.18
9	0945	3.0										.11
10	1315	2.6										.13
11	1450	6.5	.88	.71	.61	.28	.18	.18	.19	.13	.15	.15
11	1615	6.2										.15
12	1030	7.5										.12
12	1400	8.8	.72	.33	.38	.28	.18	.18	.18	.16	.17	.16
13	1030	4.5	1.1	1.1	1.0	.18	.14	.17	.14	.12	.15	.14
13	1300	3.8										.16
14	1030	2.4										.15
14	1430	4.2	.90	.82	.78	.22	.16	.18	.16	.15	.15	.16
15	1430	3.8										.17
15	1700	4.0	.36	.32	.32	.20	.19	.18	.18	.19	.18	.18
16	1230	2.8										.14
16	1800	2.8										.15
17	1015	2.8										.13
17	1912	2.4										.14
18	1000	2.8	.98	.75	.66	.27	.15	.22	.14	.12	.15	.14
18	2100	2.4										.14
19	1100	3.0	1.0	.88	.81	.29	.15	.17	.14	.12	.13	.13
19	2200	2.8										.14
20	1100	3.5	.98	.19	.19	.31	.13	.16	.13	.14	.15	.13
21	1000	7.5	2.0	2.0	1.8	.22	.15	.16	.14	.15	.15	.15
22	1800	4.0										.13
23	1100	6.0										.10
24	1000	3.8										.11
25	0930	4.0	1.3	1.1	1.0	.33	.12	.16	.09	.10	.11	.10
25	1900	3.0										.12
26		3.8	.46	.38	.35	.42	.15	.13	.13	.10	.12	.115
27	1000	2.8	.46	.38	.30	.26	.17	.16	.12	.11	.12	.12
27	1600	135.0										.13
28	1123	7.0	2.2	1.8	1.8	.33	.19	.13	.12	.10	.10	.11
28	1800	10.0										.12
29	0945	4.8	1.6	1.2	1.1	.35	.16	.17	.13	.11	.12	.11
30	0830	4.8										.11
31	1430	6.0										.11
		6.7	.88	.72	.67	.26	.16	.18	.14	.13	.15	.14

	Raw Water	Finished Water	Precent Reduction
Max NTU	135.0	.25	99.9
Ave NTU	6.7	.14	80.0
Min NTU	2.2	.10	87.0

APPENDIX B TURBIDITY ANALYSIS RESULTS

TURBIDITY AS NTU

NOV 1982	TIME	B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
1	1050	3.2	.88	.78	.69	.24	.14	.17	.12	.12	.13	.12
1	1600	3.4										.13
2	1130	3.8	.92	.79	.70	.24	.15	.18	.14	.15	.14	.14
2	1330	3.8										.14
3		3.5	1.2	1.1	1.0	.35	.18	.17	.15	.13	.14	.14
3		3.8										.13
4	0830	3.8										.14
5	0800	4.2	1.1	1.0	.9	.25	.18	.15	.13	.12	.12	.11
5		4.0										.12
6	1300	8.2										.10
8	0750	8.4										.13
8	1030	5.5	.18	.16	1.3	.45	.15	.15	.11	.13	.14	.13
10	1715	8.0										10.00*
10	2000									2.0*		.16
11		20.0										.16
11	1745	20.0										.17
12	0830	27.0	8.0	7.8	6.5	2.0	.61	.21	.15	.17	.17	.14
12		32.0										.14
13	0930											.16
14	0930	8.2										.18
15	1045	14.0	1.7	1.3	1.0	1.0	.25	.23	.12	.14	.14	.14
16		11.0	1.4	3.4	3.0	1.8	.25	.26	.16	.16	.17	.16
16		12.0										.18
17	1333	23.0	5.8	5.0	4.5	1.2	.32	.19	.13	.15	.45	.18
17		15.0										.16
18	0930	11.0	.91	1.0	.32	.85	.76	.23	.14	.17	.15	.16
18	2130	9.0										.16
19		12.0	1.1	1.0	.75	.82	.25	.21	.18	.17	.18	.18
19	1800	15.0										.18
20	0930	35.0										.17
20	1715	32.0										.16
21	0950	57.0										.13
21		48.0										.14
22	1115	12.0	6.2	5.2	4.8	1.5	.42	.50	.13	.13	.17	.13
	AVE.	14.9	2.4	2.4	2.1	.89	.31	.22	.14	.15	.18	.15

* Result of system starting up after being idle for 48 hours during work on Lake Intake Suction Piping and Screen. This entry was not used in average calculation as it is not a normal occurence. Normal shut down period is ± 11 hours.

	TURBIDITY DATA		
	Raw Water	Finished Water	Precent Reduction
Max NTU	57.0	10.0*	99.8
Ave NTU	14.9	0.13	99
Min NTU	3.2	0.10	0*

APPENDIX B TURBIDITY ANALYSIS RESULTS

1982 NOV.	TIME	B	TURBIDITY AS NTU C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
23	1100	12										.14
23	1815	11										.14
24	0945	10	1.3	1.0	.90	.95	.19	.18	.13	.12	.12	.12
24	1800	16										.12
25	0930	12										.12
25	2230	8										.13
26	1130	16										.14
26	1800	10										.12
27	1300	8										.12
28	0945	24										.14
29	1100	18	11.0	8.0	8.0	3.5	1.0	.6	.13	.14	.19	.14
29	1600	18										.13
30	1100	12	7.2	5.6	5.0	2.5	.46	.28	.13	.12	.13	.12
30	1430	12										.12
AVE.		13	6.5	4.9	4.6	2.3	.55	.35	.13	.13	.15	.13

	TURBIDITY DATA Raw Water	Finished Water	Percent Reduction
Max NTU	24.0	0.14	99
Ave NTU	13.0	0.13	99
Min NTU	8.0	0.12	98

APPENDIX B TURBIDITY ANALYSIS RESULTS

1982 NOV.	TIME	B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
			TURBIDITY AS NTU									
23	1100	12										.14
23	1815	11										.14
24	0945	10	1.3	1.0	.90	.95	.19	.18	.13	.12	.12	.12
24	1800	16										.12
25	0930	12										.12
25	2230	8										.13
26	1130	16										.14
26	1800	10										.12
27	1300	8										.12
28	0945	24										.14
29	1100	18	11.0	8.0	8.0	3.5	1.0	.6	.13	.14	.19	.14
29	1600	18										.13
30	1100	12	7.2	5.6	5.0	2.5	.46	.28	.13	.12	.13	.12
30	1430	12										.12
AVE		13	6.5	4.9	4.6	2.3	.55	.35	.13	.13	.15	.13

	TURBIDITY DATA		
	Raw Water	Finished Water	Precent Reduction
Max NTU	24.0	0.14	99
Ave NTU	13.0	0.13	99
Min NTU	8.0	0.12	98

APPENDIX B TURBIDITY ANALYSIS RESULTS

1982 DEC.	TIME	B	TURBIDITY AS NTU C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
1	1110	13	4.5	2.0	4.4	4.4	.74	.36	.12	.13	.13	.12
1		10										.12
2	1030	9.5	1.1	.95	.95	.45	.22	.24	.14	.15	.16	.14
2	1045	10.0										.12
3	1030	20	4.4	2.1	4.0	3.8	.55	.38	.12	.13	.12	.12
3	1730	38										.12
4		12										.12
5		14										.14
6	1030	18	6.6	5.4	6.2	.90	.88	.25	.10	.11	.11	.11
6	1700	14										.12
7		16										.11
7		12										.12
8	1050	6.5	4.5	4.2	3.8	2.0	1.5	1.0	.11	.11	.10	.10
8		6.0										.11
9	1030	16	4.8	3.6	3.2	3.0	2.2	3.8	.13	.11	.12	.12
9		14										.12
10		54	2.2	1.6	8.4	1.0	.15	.15	.08	.12	.12	.10
10		42										.11
11		25										
12	1100	18										.11
13		8.8	5.5	4.6	4.5	1.5	.76	.32	.14	.10	.17	.14
13		10										.16
14	1000	9.5	5.0	4.2	3.8	.52	.46	.44	.14	.10	.12	.12
14		9.0										.12
15		8	4.4	3.8	3.6	.46	.34	.32	.14	.12	.13	.12
16	1030	8.0	4.4	3.8	3.4	3.6	3.2	2.8	.11	.13	.15	.13
17	0830	10										.10
18		6										.13
19		5										.11
19		7										.10
20	1015	6.0	3.8	.34	3.2	4.5	1.2	1.0	.19	.11	.12	.15
22	0915	8.2	9.4	5.8	5.2	4.5	1.2	.95	.10	.14	.11	.12
22	1200	8.0										.18
23		6.0										.12
24		20										.10
25		98										.11
26		98										.14
27		9.8	2.4	2.2	1.0	1.6	.16	.15	.17	.12	.11	.14
28	0900	56	15.0	14	12	1.0	.58	.44	.80	.45	.35	.28
28		58										.60
29	1000	30	16	12	10	3.5	.50	.26	.19	.22	.18	.19
29		18										.12
30		16										.18
31	1000	12										.15
	Ave.	21	5.9	4.4	4.9	2.3	.92	.80	.17	.15	.14	.14

	TURBIDITY DATA Raw Water	Finished Water	Precent Reduction
Max NTU	98.0	0.60	99
Ave NTU	21.0	0.14	99
Min NTU	5.0	0.10	98

APPENDIX B TURBIDITY ANALYSIS RESULTS

1983 JAN.	TIME	B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
			TURBIDITY AS NTU									
1	1130	34										.60
1	1800	26										.14
2		20										.80
2	1315	16										.46
3	1115	15	6.6	4.5	4.0	.50	.22	.19	.17	.11	.14	.17
3		12										.12
4	1045	14	4.5	3.8	3.8	1.2	.32	.25	.14	.10	.18	.12
4	1330	10										.18
5	1100	10	2.4	1.8	2.2	1.4	.22	.20	.12	.10	.14	.12
6	1030	20	4.5	3.8	3.2	.78	.18	.16	.11	.10	.10	.10
6		18										.12
7		18										.12
8	1700	12										.09
9		10										.08
10		90	64	47	35	14	10	5.8	.28	.12	.16	.14
10		110										.30
11		30	26	25	23	15	11	6.5	1.2	.30	.51	.60
11		42										.12
12		24		5.5	4.2		1.8	1.0	.35	.23	.22	.35
12		20										.12
13		11										.08
14		12										.08
14		11										.08
15		12										.12
16		10										.11
17		14	8.4	2.8	2.5	1.1	.25	.15	.09	.12	.11	.09
17		10										.10
18		12	2.8	2.4	2.2	.85	.25	.24	.09	.11	.09	.08
18		8										.12
19		6	2.5	1.8	1.8	1.6	.90	.85	.08	.09	.06	.06
19		5										.07
20		6	4.2	4.0	3.8	1.8	.95	.85	.10	.12	.11	.09
20	1215	6										.14
21		5	3.5	2.2	2.0	1.2	.35	.30	.06	.08	.09	.06
21		5										.06
22		5										.20
23	1300	4										.07
24		3	2.4	2.2	2.2	2.2	.98	.80	.18	.18	.16	.17
24	1300	3										.13
25		2	1.6	1.2	1.0	.95	.32	.20	.06	.05	.05	.06
25		2										.11
26	1030	1.5	1	.90	.84	1.0	.13	.14	.12	.12	.10	.10
26	1300	1.5										.14
27		1.5	1	.88	.86	.85	.14	.13	.10	.10	.09	.09
28		3	1.6	.28	.25	1.0	.18	.17	.12	.10	.11	.10
29		4										.12
30		2										.12
30		3										.10
31		3	2.7	3.0	1.5	2.0	.5	.3	.19	.17	.18	.18
		15	8.2	6.3	5.2	2.8	1.6	1.01	.20	.13	.14	.16

TURBIDITY DATA

	Raw Water	Finished Water	Precent Reduction
Max NTU	110.0	0.80	99
Ave NTU	15.0	0.16	98
Min NTU	1.5	0.06	93

APPENDIX B TURBIDITY ANALYSIS RESULTS

1983 FEB.	TIME	B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
			TURBIDITY AS NTU									
1		3	1.0	.86	.7	4.0	.4	.15	.16	.17	.15	.14
1		3										.16
2		2.5	1.8	1.6	1.6	2.2	.82	.48	.16	.15	.17	.17
2	1630	3										.40
3		4	2.4	2.2	2.0	1.4	.28	.25	.13	.12	.11	.11
3		5										.12
4		4										.12
4		3										.08
5	1000	3										.11
5		3										.11
6		3										.10
6		3										.10
7		1.2	1.1	.76	.75	2.8	.14	.15	.18	.13	.2	.18
7		3										.18
8		2.7	2.9	2.4	2.5	2.1	1.0	.70	.20	.25	.35	.19
8		3										.18
9	1030	3.4	4.7	2.7	3.3	4.6	.54	.47	.16	.16	.17	.15
9		5										.12
10		5	3.7	3.5	3.2	7.5	1.3	.82	.27	.36	.35	.30
10		6										.20
11		3										.03
12		3	2.0	1.0	1.5	1.7	.23	.2	.15	.15	.17	.14
12		3										.16
13		3										.12
14	1100	4	1.6	1.5	1.5	1.6	.37	.24	.13	.14	.16	.14
14		3.5										.14
15		3	2.4	2.4	2.2	1.2	.26	.19	.14	.12	.14	.16
15		4										.18
16		3.1	1.6	1.2	1.2	3.2	.29	.30	.19	.17	.17	.15
16		3										.14
17	1015	2.6	1.5	1.4	1.3	.65	.19	.18	.15	.17	.17	.13
17		3										.12
18		2	1.8	1.6	1.6	.25	.24	.22	.10	.11	.12	.12
18		2.5										.14
19		3										.16
20	1430	4										.14
20		5										.14
21		3	2.5	1.6	1.8	.28	.22	.20	.15	.15	.16	.16
21		4										.12
22		2.5	1.5	1.6	1.5	.38	.34	.28	.17	.14	.16	.15
22	1300	4										.14
		3	2.2	1.8	1.8	2.26	.44	.32	.16	.17	.18	.15

	TURBIDITY DATA		
	Raw Water	Finished Water	Precent Reduction
Max NTU	6.0	0.40	99
Ave NTU	3.34	0.15	95
Min NTU	1.2	0.03	85

APPENDIX B TURBIDITY ANALYSIS RESULTS

1933 FEB.	TIME	TURBIDITY AS NTU B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
23		4	1.8	1.4	1.4	.26	.24	.22	.16	.15	.17	.16
23		4.5										.19
24	1000	3.5	.87	.85	.80	.19	.17	.18	.15	.13	.12	.12
24	1200	3.0										.11
25		3.0	1.8	1.2	1.2	.28	.24	.20	.12	.14	.12	.11
25		3.0										.14
26		3.0										.16
27		2.8	1.4	1.4	1.2	.25	.18	.19	.14	.15	.15	.14
28		1.3	1.3	.8	.7	.9	.18	.19	.18	.16	.15	.18
28		1.3										.18
		—	—	—	—	—	—	—	—	—	—	—
AVE		2.9	1.4	1.1	1.1	.38	.20	.20	.15	.15	.14	.15

	TURBIDITY DATA Raw Water	Finished Water	Precent Reduction
Max NTU	4.5	0.19	96
Ave NTU	2.9	0.15	95
Min NTU	1.3	0.11	92

APPENDIX B TURBIDITY ANALYSIS RESULTS

TURBIDITY AS NTU

MARCH	TIME	B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
1	0820	1.2	.7	.7	.66	.25	.25	.22	.22	.15	.2	.22
1	2015	1.2										.23
2	1035	3.6	.9	.8	.9	1.0	.17	.17	.16	.13	.16	.16
2		3.5										.16
3	1245	1.5	1.3	.9	.85	.93	.23	.18	.15	.15	.14	.14
4	1355	2.0	.79	.75	.69	.56	.19	.3	.16	.21	.17	.15
5		2.5										.15
5	1700	2.4										.15
6	1155	28										.17
6	1515	20										.16
7	1445	13	8.0	8.0	3.0	2.0	1.0	.55	.32	.32	.34	.44
7		11										.17
8	1050	19	3.9	.37	2.6	.8	3.5	.35	.17	.14	.14	.14
8		20										.16
9	0720	17	3.0	2.5	2.2	.5	.22	.22	.17	.17	.22	.16
9	1530	16										.17
10	1000	9.5	4.6	4.0	3.5	.8	.2	.16	.15	.16	.16	.14
11		7.5	2.3	2.0	1.6	.7	.18	.19	.12	.13	.15	.15
12		15										.15
13	1400	10										.14
14	1435	5.0	1.9	1.8	1.8	2.1	.23	.23	.15	.3	.15	.15
14	1745	6.0										.15
15	0930	4.8	1.0	1.5	1.8	1.5	.5	.25	.16	.16	.18	.15
15	1535	7.2										.13
16	0855	4.3	1.6	1.5	1.2	.62	.25	.19	.14	.15	.15	.14
16	1435	6.0										.14
17	1305	12	2.6	2.5	1.8	.86	.23	.18	.15	.13	.16	.15
18		6.5	1.4	1.2	1.2	.98	.21	.31	.15	.16	.14	.14
18	1450	6.5										.12
19		5.6										.11
19		5.0										.12
20	1730	6.5										.15
21	0915	4.5	1.2	1.0	.9	.34	.26	.24	.12	.26	.16	.16
22		8.1	1.8	2.7	2.0	.38	.32	.35	.16	.19	.3	.25
22		20										.16
23	1000	37	15.0	15.0	15.0	.69	.55	.43	.23	.23	.25	.25
23	1700	38										.17
24	0630	24										.16
24	1045	18	6.3	7.8	5.6	.65	.68	.6	.25	.2	.8	.17
25		20	6.2	7.4	5.4	.68	.64	.62	.22	.23	.25	.25
25		20										.24
26	1415	11										.24
27	1035	56										.18
27	1545	44										.19
28		18	5.8	5.6	4.4	.4	.42	.28	.9	.18	.19	.12
29		24	6.5	5.6	5.1	.3	.3	.35	.22	.22	.14	.14
29		15										.14
30		14	5.0	4.5	3.5	.35	.23	.19	.12	.15	.17	.12
31		7.4	2.9	2.5	2.1	.39	.18	.23	.14	.15	.15	.15
31		7.0										.15
		13.3	3.7	3.5	2.9	.87	.48	.29	.21	.19	.21	.17

TURBIDITY DATA	Raw Water	Finished Water	Precent Reduction
Max NTU	56	0.44	99
Ave NTU	13.3	0.17	99
Min NTU	1.2	0.11	91

APPENDIX B TURBIDITY ANALYSIS RESULTS

			TURBIDITY AS NTU									
APRIL	TIME	B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
1		7										.12
2		7										.13
3	1030	20										.14
4		13	1.8	1.5	1.2	.24	.2	.22	.17	.13	.17	.15
5		9.8	7.5	2.0	1.5	.48	.45	.47	.18	.15	.17	.14
5	1700	7.0										.14
6	0745	6										.16
6	1430	6.0	1.9	1.7	1.6	.85	.42	.41	.22	.18	.20	.20
7	0745	5.0	1.8	1.6	1.5	.45	.21	.26	.14	.19	.16	.16
7	1500	4.0										.14
8		15	2.0	1.1	1.4	.38	.24	.22	.15	.15	.14	.14
8	1800	12										.19
9	1004	9										.17
11	1015	9.5	3.1	1.7	1.8	1.6	.78	.38	.18	.18	.19	.17
11	1530	8.0										.19
12		15	4.6	4.4	4.0	.38	.36	.33	.33	.34	.24	.26
12		15										.20
13	0800	22										.30
13	1300	14	2.0	1.6	1.8	.45	.34	.36	.20	.19	.20	.20
14	1045	98	14	10	9.5	.45	.30	.32	.19	.18	.19	.18
14	1400	98										.18
14	2230	150										.25
15	0730	40	10	11	1.5	2.5	1.6	.68	.4	.15	.20	.22
15	1515	32										.32
16	0800	26										.22
17		22										.45
18		14*										1.5 *(BW)
18	1000	17	4.7	3.9	3.0	.55	.34	.31	.16	.25	.25	.4
19		20										1.5
19	1540	24			2.8			.26		.42		.40
20		12	2.8	2.2	1.7	.17	.23	.21	.16	.12	.22	.13
20	1215	8										.13
21		6										.30
21		5										.13
22	1030	6	1.6	1.3	1.5	.54	.22	.27	.11	.15	.14	.12
22		8										.12
23	1115	5										.11
24		17										.15
25		23	9.0	7.8	7.1	.69	.49	.47	.20	.25	.19	.17
25		20										.15
26	1100	7	1.3	1.2	.9	.46	.45	.44	.19	.22	.20	.14
26		7										
27	1130	7	3.5	2.6	2.5	.29	.28	.25	.16	.13	.17	.14
27	1600	6										.12
28		6	1.4	1.3	1.2	.45	.20	.25	.17	.16	.19	.18
28		6										.17
29		8										.18
29		6.9	1.8	1.6	1.5	.23	.23	.32	.54	.36	.46	.32
30	0830	8										.13
		18.7	4.1	3.2	2.5	.39	.33	.34	.21	.20	.20	.18

TURBIDITY DATA

	Raw Water	Finished Water	Precent Reduction
Max NTU	150.0	1.5 (BW)	99
Ave NTU	18.7	.18	99
Min NTU	4.0	0.11	97

(BW) During Backwash

APPENDIX B TURBIDITY ANALYSIS RESULTS

TURBIDITY AS NTU

MAY	TIME	B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
												.14
1	1200	22										
		20	8.4	6.3	5.6	1.2	.38	.35	.16	.15	.15	.16
2												.16
2	1400	22										
3	0845	22	5.5	3.6	2.0	2.0	.22	.18	.47	.3	.4	.45
												.25
3		14										
4	1300	9	3.3	2.8	2.1	.79	.25	.45	.31	.37	.4	.35
												.20
4	1600	8										
5		7.5	3.2	3.0	2.6	.44	.18	.18	.20	.18	.20	.19
												.20
5		6.8										
6	0745	3.7	1.8	1.5	1.4	.3	.23	.28	.18	.17	.22	.18
												.16
6		4.0										
7	1015	15										.40
												.25
8		25										
9		6.2	2.2	1.2	.90	.65	.20	.23	.27	.25	.23	.28
												.22
9		5.8										
10		5.9										.3
												.25
10	2215	5.0										
11		3.8	1.4	1.2	1.0	.32	.15	.19	.19	.15	.20	.17
												.25
11	1700	6.0										
12		2.5	1.2	1.2	1.0	.32	.25	.18	.16	.19	.17	.17
												.17
12		3.2										
13		2.5	1.0	.88	.82	.35	.18	.16	.17	.14	.18	.18
												.18
13		2.5										
14		3.5										.15
												.16
15		7										
16		3.8	1.2	.98	.83	.38	.19	.16	.14	.18	.16	.16
												.17
16		3.2										
17	0955	5.8	1.0	.98	.84	.39	.19	.17	.14	.16	.17	.17
												.18
17		5.4										.16
18	0800	5.0										
18	1100	3.5	.95	.62	.57	.30	.18	.16	.21	.16	.18	.12
												.12
19	0900	14										
19		13	1.8	1.5	1.3	.35	.16	.17	.16	.13	.14	.14
												.17
20		30										
20		34	10	9	10	4.5	4.4	4.6	.45	.40	.42	.35
												.18
21		13										.04
22		10										
		—	—	—	—	—	—	—	—	—	—	—
	AVE	10.1	3.1	2.5	2.21	.88	.51	.53	.23	.21	.23	.20

	TURBIDITY DATA		
	Raw Water	Finished Water	Precent Reduction
Max NTU	34.0	0.45	99
Ave NTU	10.1	0.20	98
Min NTU	2.5	0.04	98

APPENDIX B TURBIDITY ANALYSIS RESULTS

		TURBIDITY AS NTU									
MAY	TIME	B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
23	0800	16										.20
23	1045		1.2	1.0	.91	.65	.32	.52	.30	.23	.25	.25
24		8.6	2.2	1.8	1.6	.30	.21	.20	.22	.19	.18	.18
24	1500	10										.20
25		9.8	1.4	.88	.68	.58	.31	.40	.19	.20	.19	.18
25		11										.18
26	1030	8.2	1.1	.77	.79	.47	.35	.30	.19	.22	.21	.20
27		10	1.4	.90	.88	.34	.28	.25	.20	.21	.19	.18
27		8										.19
28		12										.19
29		17										.21
30		10										.20
30		13										.20
31		11	1.2	.94	.92	.39	.31	.30	.20	.17	.18	.19
31		13										.18

	TURBIDITY DATA		
	Raw Water	Finished Water	Precent Reduction
Max NTU	17.0	.25	99
Ave NTU	11.4	.20	98
Min NTU	8.2	.19	98

APPENDIX B TURBIDITY ANALYSIS RESULTS

		TURBIDITY AS NTU										
JUNE	TIME	B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
1		6.4	.98	.88	.82	.34	.30	.28	.21	.21	.19	.13
2		8										.16
2		6.5	1.0	.74	.70	.39	.26	.25	.17	.16	.14	.15
3		4.4	1.0	.7	.79	.4	.28	.35	.22	.26	.22	.22
3		10										.17
4	0650	5.8										.25
6		6	1.4	1.2	1.0	.56	.55	.52	.15	.19	.18	.16
6		8										.13
7		5.2	.95	.40	.34	.44	.23	.21	.16	.14	.13	.15
7		6										.13
8		4.8	.84	.45	.60	.46	.25	.22	.16	.18	.17	.15
8		8										.14
9		6										.22
9		4.2	1.8	1.2	1.0	.34	.24	.25	.17	.18	.17	.16
10	1330	7.3	3.9	2.0	1.7	.9	.3	.37	.19	.25	.25	.17
11		8										.20
12		8										.27
13		8.0	1.1	.70	.70	.56	.44	.30	.22	.21	.25	.24
13		10										.22
14		12										.20
14	1300	11.6	2.4	1.6	1.2	.96	.26	.32	.29	.19	.20	.20
15		5.8	.79	.30	.40	.40	.20	.24	.18	.16	.19	.13
15		11										.19
16		12										.22
16		5										.13
17		4.7	1.5	.71	.54	.9	.32	.34	.27	.26	.45	.25
18		4.8										.25
19	1530	4.9										.20
20		7.4										.20
20		7.8	1.1	.47	.46	.34	.30	.28	.22	.21	.20	.21
21		8										.18
21		7.2	.40	.34	.32	.28	.25	.24	.18	.20	.20	.19
22		8										.20
22		7.6	1.2	.75	.75	.42	.34	.32	.20	.22	.21	.22
23		9										.22
23		8.4	1.3	.48	.40	.38	.25	.22	.19	.17	.19	.20
24		12										.18
24		11	1.6	.50	.46	.50	.26	.23	.19	.19	.15	.17
25		8										.17
25		8										.16
26		9										.22
30	1145	5.9										.25

	TURBIDITY DATA		
	Raw Water	Finished Water	Precent Reduction
Max NTU	12	.27	98
Ave NTU	7.6	.19	97
Min NTU	4.4	.14	97

APPENDIX B TURBIDITY ANALYSIS RESULTS

		TURBIDITY AS NTU									
JULY	TIME	B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
1		5										.9
2		3										.22
2		4										.21
3		7										.22
4		5										.21
5		5										.19
5		5										.19
6		5										.22
6			1.4	.42	.30	.35	.34	.32	.15	.12	.21	.21
7		3.5	.65	.32	.25	.44	.28	.30	.18	.20	.20	.19
7		4										.18
9	1410	4										.19
10	1245	2.5										.36
10		2.5										.26
11		4.5	1.0	3.4	3.6	2.3	.87	.65	.26	.26	.3	.23
12	1145	5.4	3.1	.5	.45	.66	.34	.32	.3	.26	.29	.29
14	1530	4										.22
16		4										.45
17		6										.4
18		3.5	1.1	1.0	.95	1.5	.64	.65	.46	.40	.36	.42
18	1705	4										.35
19		5										.45
19		5.8	.82	.45	.48	.75	.17	.17	.17	.19	.16	.13
20		6.2	.88	.47	.45	.70	.20	.22	.20	.16	.19	.16
21		3.8	1.2	.82	.46	1.4	.3	.22	.20	.16	.20	.10
22		3.2										.28
23		4.5										.30
24		4.8						BH				.35
24	2000	6.2										.16
25		4.6										.13
25		3.8	.54	.40	.38	.54	.32	.28	.17	.19	.20	.13
26		5.2										.40
26		6.2	1.4	1.2	.98	.82	.61	.58	.40	.35	.36	.33
27		4.2										.33
27		4.8	.52	.35	.50	2.2	.48	.30	.26	.24	.28	.22
28		6.4	1.5	1.1	1.1	1.8	.92	.85	.58	.58	.62	.09
28		6.2										.15
29		2.8	.44	.26	.23	.24	.21	.19	.11	.10	.14	.09
30		3.0										.24
30	1430	3.8										.15
31		4										.13

	TURBIDITY DATA		
	Raw Water	Finished Water	Precent Reduction
Max NTU	7.0	.9	87
Ave NTU	4.5	.28	94
Min NTU	3.0	.09	97

APPENDIX B TURBIDITY ANALYSIS RESULTS

AUGUST	TIME	B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
1	0800	7										.13
1	1300	2.2	.55	.31	.26		.19	.19	.16	.16	.16	.16
2		2.8	.72	.43	.46		.44	.35	.40	.38	.40	.38
2		2.4										.13
3		5.2	.98	.88	.92		.42	.40	.22	.23	.23	.22
3		4.8										.22
4		3.8										.30
4		2.8	1.0	.39	.40		.32	.28	.22	.20	.25	.20
5		3.0										.22
6		2.0										.50
7		3.8										.35
7	1900	3.6										.20
8		1.8	2.1	.75	.7	2.4	.5	.5	.35	.45	.35	.4
8		4.0										.52
9		4.2										.15
9		4.2	.32	.16	.22		.22	.20	.20	.20	.18	.18
10		3										.11
10		3.2	.88	.64	.64		.20	.15	.17	.17	.13	.12
11		3.6										.11
11		3.4	.45	.28	.19		.19	.17	.19	.18	.16	.15
12		3.2	.59	.31	.35	.48	.27	.23	.23	.23	.27	.25
12	1030	3.0										.20
13	1235	3.0										.19
14		3.8										.17
15	0700	4										.18
15		3.8	.56	.36	.36	.98	.18	.23	.21	.19	.19	.19
16		3.8										.20
16		3.8	.50	.32	.35	.70	.24	.32	.18	.20	.23	.20
17		5.6	.75	.39	.38	.75	.33	.35	.20	.20	.18	.18
17		5.8										.24
18		4.6	1.0	.63	.65	1.1	.25	.28	.21	.22	.20	.20
18		4.4										.16
19	0900	6										.25
20		4.2										.18
21		3.6										.16
21		4.8										.17
22		2.4										.15
22		2.4	.95	.34	.38	.71	.26	.23	.16	.19	.18	.18
23		2.2	1.2	.32	.28	.65	.20	.25	.16	.18	.18	.16
23		2.1										.18
24	1030	2.4										.17
25		4.4										.15
25		3.2	.98	.28	.28	1.0	.18	.25	.20	.21	.20	.20
26	1345	3.5										.22
27	1030	3.0										.19
28	1215	3										.17
29	0700	3										.20
29		2.8	.72	.37	.38	1.0	.29	.26	.19	.20	.20	.19
30	1300	3										.17
30	1315	2.6	.68	.34	.35	1.0	.27	.24	.15	.15	.16	.17
31		4.2										.18
31		2.8	1.8	.30	.24	.35	.22	.21	.17	.21	.21	.19

TURBIDITY DATA

	Raw Water	Finished Water	Percent Reduction
Max NTU	7.0	.52	93
Ave NTU	3.6	.21	94
Min NTU	1.8	.11	99

B.) APPENDIX C PERCENT TURBIDITY REDUCTION THROUGH SYSTEM
STARTING SEPTEMBER 1 THRU SEPTEMBER 30, 1982
RAW WATER TURBIDITY RANGE 1.5 - 5.00 NTU

$$(1 - \frac{\text{TURBIDITY AS NTU AT SAMPLE POINT}}{\text{RAW WATER TURBIDITY AS NTU}})\ (100) = \text{PERCENT REDUCTION}$$

SEPT.	ROCK FILTER	MIXED MEDIA FILTER	CARBON FILTER	BUBBLE TRAP
1	73	77	87	88
2	79	83	90	92
3	79	80	81	92
7	84	89	93	94
8	79	84	90	92
9	84	90	94	94
10	67	75	84	87
13	73	82	91	92
14	86	89	91	94
15	93	95	96	98
16	85	92	94	94
17	84	91	94	95
20	91	94	96	96
21	81	88	93	94
22	91	95	95	96
23	86	92	93	95
24	85	85	92	92
27	08	96	96	97
28	80	85	91	93
29	85	89	93	94
30	62	81	83	91
AVE	82	87	91	93
MIN	62	75	81	87
MAX	93	96	96	98

NOTE: Apparent reduction from carbon filter effluent through bubble trap Ave. 2%. This represents deaeration of sample.

B.) APPENDIX C PERCENT TURBIDITY REDUCTION THROUGH SYSTEM
STARTING OCTOBER 1 THRU OCTOBER 29, 1982
RAW WATER TURBIDITY RANGE 2.2 - 135.0 NTU

$$(1 - \frac{\text{TURBIDITY AS NTU AT SAMPLE POINT}}{\text{RAW WATER TURBIDITY AS NTU}})\ (100) = \text{PERCENT REDUCTION}$$

OCT.	ROCK FILTER	MIXED MEDIA FILTER	CARBON FILTER	BUBBLE TRAP
1	88	91	93	92
4	80	96	97	97
5	92	95	96	93
6	87	94	96	96
7	84	91	92	93
8	8º	94	95	95
11	89	97	98	98
12	95	98	98	98
13	76	96	97	97
14	80	96	96	96
15	92	95	95	96
18	72	92	95	95
19	70	93	96	96
20	87	94	96	96
21	74	98	98	98
25	72	95	98	98
26	90	94	97	97
27	86	93	96	96
28	72	97	99	98
29	73	95	98	98
	—	—	—	—
AVE	82	95	96	96
MIN	70	91	92	92
MAX	95	98	99	98

B.) APPENDIX C PERCENT TURBIDITY REDUCTION THROUGH SYSTEM
STARTING NOVEMBER 1 THROUGH NOVEMBER 22, 1982
RAW WATER TURBIDITY RANGE 3.2 - 57.0 NTU

$$(1 - \frac{\text{TURBIDITY AS NTU AT SAMPLE POINT}}{\text{RAW WATER TURBIDITY AS NTU}})\ (100) = \text{PERCENT REDUCTION}$$

NOV.	ROCK FILTER	MIXED MEDIA FILTER	CARBON FILTER	BUBBLE TRAP
1	76	94	96	96
2	79	95	96	96
3	69	93	96	96
5	76	95	97	97
8	90	95	98	98
11	-	-	-	99
12	72	97	99	99
14	-	-	-	98
15	90	96	99	99
16	76	93	99	99
17	78	98	99	99
18	93	94	99	99
19	92	96	99	99
20	-	-	-	99
21	-	-	-	99
22	55	93	99	99
AVE	79	95	98	98
MIN	55	93	96	96
MAX	93	98	99	99

B.) APPENDIX C PERCENT TURBIDITY REDUCTION THROUGH SYSTEM
STARTING NOVEMBER 23 THROUGH NOVEMBER 30, 1932
RAW WATER TURBIDITY RANGE 3.0 - 24.0 NTU

$$(1 - \frac{\text{TURBIDITY AS NTU AT SAMPLE POINT}}{\text{RAW WATER TURBIDITY AS NTU}})\ (100) = \text{PERCENT REDUCTION}$$

NOV. 1982	ROCK FILTER	MIXED MEDIA FILTER	CARBON FILTER	BUBBLE TRAP
23				99
24	89	87	96	99
25				99
26				99
27				98
28				99
29	50	90	99	99
30	50	91	99	99
AVE.	63	89	98	99
MAX	89	91	99	99
MIN	50	87	96	98

APPENDIX C PERCENT TURBIDITY REDUCTION THROUGH SYSTEM
STARTING DECEMBER 1 THROUGH DECEMBER 31, 1982
RAW WATER TURBIDITY RANGE 5.0 - 98.0 NTU

$$\left(1 - \frac{\text{TURBIDITY AS NTU AT SAMPLE POINT}}{\text{RAW WATER TURBIDITY AS NTU}}\right)(100) = \text{PERCENT REDUCTION}$$

DEC 1982	ROCK FILTER	MIXED MEDIA FILTER	CARBON FILTER	BUBBLE TRAP
1	72	86	99	99
2	89	97	98	99
3	83	92	99	99
4				99
5				99
6	66	96	99	99
7				99
8	36	77	98	98
9	76	81	99	99
10	71	99	99	99
12				99
13	45	90	98	98
14	54	95	99	99
15	51	95	98	99
16	52	60	98	98
17				99
18				98
19				98
20	42	63	98	98
22	17	73	99	99
23				98
24				99
25				99
26				99
27	81	94	99	99
28	76	99	99	99
29	58	95	99	99
30				99
31				99
AVE.	61	87	99	99
MAX.	89	99	99	99
MIN.	17	60	98	98

B.)APPENDIX C PERCENT TURBIDITY REDUCTION THROUGH SYSTEM
STARTING JANUARY 1 THROUGH JANUARY 31, 1983
RAW WATER TURBIDITY RANGE 1.5 - 110.0 NTU

$$(1 - \frac{\text{TURBIDITY AS NTU AT SAMPLE POINT}}{\text{RAW WATER TURBIDITY AS NTU}})\ (100) = \text{PERCENT REDUCTION}$$

JAN. 1983	ROCK FILTER	MIXED MEDIA FILTER	CARBON FILTER	BUBBLE TRAP
1				98
2				96
3	66	98	99	99
4	71	96	99	99
5	79	94	99	99
6	81	98	99	99
7				99
8				99
9				99
10	46	89	99	99
11	18	64	99	98
12	80	94	99	99
13				99
14				99
15				99
16				99
17	67	96	99	99
18	79	96	99	99
19	66	81	99	99
20	33	80	98	99
21	49	88	99	99
22				96
23				98
24	24	78	94	94
25	37	76	97	97
26	39	72	92	93
27	39	75	94	94
28	76	85	96	97
29				97
30				94
31	20	69	94	94
AVE.	53	85	97	98
MAX.	81	98	99	99
MIN	18	64	92	94

B.) APPENDIX C PERCENT TURBIDITY REDUCTION THROUGH SYSTEM
STARTING FEBRUARY 1 THROUGH FEBRUARY 22, 1983
RAW WATER TURBIDITY RANGE 1.2 - 6.0 NTU

$$\left(1 - \frac{\text{TURBIDITY AS NTU AT SAMPLE POINT}}{\text{RAW WATER TURBIDITY AS NTU}}\right)(100) = \text{PERCENT REDUCTION}$$

FEB. 1983	ROCK FILTER	MIXED MEDIA FILTER	CARBON FILTER	BUBBLE TRAP
1	72	49	95	95
2	33	53	94	93
3	45	84	97	97
4				97
5				96
6				97
7	28	14	86	85
8	4	53	90	93
9	12	45	95	96
10	31	36	93	94
11				99
12	40	76	95	95
13				96
14	62	82	96	97
15	22	82	96	95
16	57	59	94	95
17	46	87	94	95
18	17	88	95	94
19				95
20				97
21	34	92	95	95
22	39	87	94	94
	---	---	---	---
AVE.	36	66	94	95
MAX.	72	92	97	99
MIN.	4	14	86	85

B.) APPENDIX C PERCENT TURBIDITY REDUCTION THROUGH SYSTEM

STARTING February 22 through February 28, 1983

RAW WATER TURBIDITY RANGE

$$(1 - \frac{\text{TURBIDITY AS NTU AT SAMPLE POINT}}{\text{RAW WATER TURBIDITY AS NTU}})\ (100) = \text{PERCENT REDUCTION}$$

FEB.	ROCK FILTER	MIXED MEDIA FILTER	CARBON FILTER	BUBBLE TRAP
23	62	94	96	96
24	76	95	96	96
25	53	92	96	96
26	-	-	-	-
27	52	93	95	95
28	28	67	87	86
	—	—	—	—
AVE..	54	88	94	94
MAX.	76	95	96	96
MIN.	28	67	87	86

B.) APPENDIX C PERCENT TURBIDITY REDUCTION THROUGH SYSTEM
STARTING March 1 through March 31, 1933
RAW WATER TURBIDITY RANGE

$$(1 - \frac{\text{TURBIDITY AS NTU AT SAMPLE POINT}}{\text{RAW WATER TURBIDITY AS NTU}})\ (100) = \text{PERCENT REDUCTION}$$

MARCH	ROCK FILTER	MIXED MEDIA FILTER	CARBON FILTER	BUBBLE TRAP
1	43	80	84	82
2	76	88	96	96
3	32	70	90	91
4	63	83	91	93
5				94
6				99
7	51	91	97	97
8	88	92	99	99
9	85	98	99	99
10	58	96	98	99
11	74	95	98	98
12				99
13				99
14	63	83	96	97
15	70	84	97	97
16	67	92	97	97
17	81	96	99	99
18	81	92	98	98
19				98
20				98
21	77	94	96	96
22	73	96	97	97
23	59	98	99	99
24	64	96	98	99
25	68	97	99	99
26				98
27				99
28	71	98	98	99
29	76	99	99	99
30	69	98	99	99
31	66	96	98	98
	—	—	—	—
AVE.	68	92	97	97
MAX.	88	99	99	99
MIN.	32	70	84	82

B.) APPENDIX C PERCENT TURBIDITY REDUCTION THROUGH SYSTEM
STARTING April 1 through April 30, 1983
RAW WATER TURBIDITY RANGE

$$(1 - \frac{\text{TURBIDITY AS NTU AT SAMPLE POINT}}{\text{RAW WATER TURBIDITY AS NTU}})\ (100) = \text{PERCENT REDUCTION}$$

APRIL	ROCK FILTER	MIXED MEDIA FILTER	CARBON FILTER	BUBBLE TRAP
4	88	98	99	99
5	75	94	98	98
6	71	91	97	97
7	67	94	97	97
8	90	98	99	99
9				
10				
11	77	90	98	98
12	71	98	98	98
13	87	97	98	98
14	88	99	99	99
15	81	96	99	99
16				
17				
18	77	98	99	98
19	88	99	98	98
20	81	98	99	99
21				
22	75	94	98	98
23				
24				
25	65	98	99	99
26	84	93	97	98
27	59	96	98	98
28	78	95	97	97
29	76	96	93	95
30				
	—	—	—	—
AVE	78	96	98	98
MAX	90	99	99	99
MIN	59	90	93	95

B.) APPENDIX C PERCENT TURBIDITY REDUCTION THROUGH SYSTEM
STARTING May 1 through May 22, 1983
RAW WATER TURBIDITY RANGE

$$(1 - \frac{\text{TURBIDITY AS NTU AT SAMPLE POINT}}{\text{RAW WATER TURBIDITY AS NTU}})\ (100) = \text{PERCENT REDUCTION}$$

MAY	ROCK FILTER	MIXED MEDIA FILTER	CARBON FILTER	BUBBLE TRAP
1				
2	65	97	99	99
3	83	96	98	98
4	69	94	96	96
5	61	96	97	97
6	58	93	95	95
7				
8				
9	77	94	96	95
10				
11	68	94	95	96
12	55	90	93	93
13	64	91	93	93
14				
15				
16	74	94	96	96
17	84	96	97	97
18	79	94	95	96
19	88	98	99	99
20	71	87	99	99
21				
22	—	—	—	—
AVE.	71	94	96	96
MAX.	88	97	99	99
MIN.	55	87	93	93

B.) APPENDIX C PERCENT TURBIDITY REDUCTION THROUGH SYSTEM
STARTING MAY 23 THROUGH MAY 31, 1983
RAW WATER TURBIDITY RANGE

$$(1 - \frac{\text{TURBIDITY AS NTU AT SAMPLE POINT}}{\text{RAW WATER TURBIDITY AS NTU}})\ (100) = \text{PERCENT REDUCTION}$$

MAY	ROCK FILTER	MIXED MEDIA FILTER	CARBON FILTER	BUBBLE TRAP
24	78	97	98	98
25	90	96	98	98
26	89	95	97	97
27	89	97	98	98
28	-	-	-	-
29	-	-	-	-
30	-	-	-	-
31	91	97	98	98
AVE	87	97	98	98
MAX	91	97	98	98
MIN	78	95	97	98

B.) APPENDIX C PERCENT TURBIDITY REDUCTION THROUGH SYSTEM
STARTING JUNE 1 - JUNE 30
RAW WATER TURBIDITY RANGE 33 - 92

$$(1 - \frac{\text{TURBIDITY AS NTU AT SAMPLE POINT}}{\text{RAW WATER TURBIDITY AS NTU}})\ (100) = \text{PERCENT REDUCTION}$$

JUNE	ROCK FILTER	MIXED MEDIA FILTER	CARBON FILTER	BUBBLE TRAP
1	86	95	96	97
3	81	92	95	95
6	86	91	97	97
7	89	94	97	99
8	86	94	96	97
10	33	77	90	93
13	90	95	97	97
15	92	95	97	97
17	80	89	93	95
AVE	80	91	95	96
MAX	92	95	93	99
MIN	33	77	97	93

B.)APPENDIX C PERCENT TURBIDITY REDUCTION THROUGH SYSTEM

STARTING JULY 1, 1983
RAW WATER TURBIDITY RANGE 50-90

$$(1 - \frac{\text{TURBIDITY AS NTU AT SAMPLE POINT}}{\text{RAW WATER TURBIDITY AS NTU}})\ (100) = \text{PERCENT REDUCTION}$$

JULY	ROCK FILTER	MIXED MEDIA FILTER	CARBON FILTER	BUBBLE TRAP
7	87	90	94	95
11	41	72	94	94
12	50	92	95	95
18	71	74	88	88
20	90	94	97	97
21	78	83	95	95
28	80	81	91	90
29	89	92	96	97
AVE	73	85	94	94
MAX	90	92	97	97
MIN	50	74	88	88

B.) APPENDIX C PERCENT TURBIDITY REDUCTION THROUGH SYSTEM
STARTING AUGUST 1, 1933
RAW WATER TURBIDITY RANGE 34 - 90

$$(1 - \frac{\text{TURBIDITY AS NTU AT SAMPLE POINT}}{\text{RAW WATER TURBIDITY AS NTU}})\ (100) = \text{PERCENT REDUCTION}$$

AUG	ROCK FILTER	MIXED MEDIA FILTER	CARBON FILTER	BUBBLE TRAP
2	80	86	86	86
3	82	92	96	96
8	34	37	79	78
12	87	90	92	92
17	90	91	97	97
18	83	88	95	96
23	72	83	92	93
AVE	75	81	91	91
MAX	90	92	97	97
MIN	34	37	79	78

VII. PH and Temperature Characteristics of Raw and Filtered Waters:

A.) Following is a tabulation of the results of PH analysis of water samples collected from September 1 through September 30, 1982.

Sept.	B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
1	8.6	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
2	8.8	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	7.9
3	8.6	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.9
4											
5											
6											
7	8.8	8.2	8.2	8.2	8.2	8.2	8.2	8.1	8.1	8.1	8.1
8	8.5	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
9	8.8	8.2	8.2	8.2	8.2	8.2	8.2	8.1	8.1	8.1	8.1
10	8.8	8.5	8.5	8.5	8.5	8.5	8.5	8.4	8.4	8.4	8.4
11											
12											
13	8.8	8.4	8.4	8.4	8.4	8.4	8.4	8.3	8.3	8.3	8.3
14	8.7	8.2	8.2	8.2	8.2	8.2	8.2	8.1	8.1	8.1	8.1
15	8.3	8.2	8.2	8.2	8.1	8.1	8.1	8.0	8.0	8.0	8.0
16	8.2	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.0
17	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.3	8.3	8.3	8.3
18											
19											
20	7.9	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
21	8.0	8.0	8.0	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9
22	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.6	7.6	7.6	7.6
23	7.6	7.6	7.6	7.6	7.5	7.5	7.5	7.5	7.5	7.5	7.5
24	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.4	7.4	7.4	7.4
25											
26											
27	7.2	7.2	7.2	7.2	7.3	7.3	7.3	7.3	7.3	7.3	7.3
28	7.4	7.4	7.4	7.4	7.3	7.3	7.3	7.3	7.3	7.3	7.3
29	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.1	7.1	7.1	7.1
30	8.8	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
	AVG.8.2										AVG.7.8
	MAX.8.8										MAX.8.4
	MIN.7.2										MIN.7.1

VII. PH and Temperature Characteristics of Raw and Filtered Waters:

A.) Following is a tabulation of the results of PH analysis of water samples collected from October 1 through October 31, 1982

Oct.	B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
1	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.7	7.7	7.7	7.7
2											
3											
4	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
5	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
6	8.1	8.1	8.1	8.1	8.0	8.0	8.0	8.0	8.0	8.0	8.0
7	8.1	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
8	8.3	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2
9											
10											
11	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
12	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
13	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
14	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
15	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
16											
17											
18	6.6	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
19	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.7	6.7	6.7	6.7
20	7.0	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
21	6.6	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
22											
23											
24											
25	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
26	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
27	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
28	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
29	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
30											
31	—										—
AVG.	7.4									AVG.	7.4
MAX.	8.3									MAX.	8.2
MIN.	6.6									MIN.	6.5

VII. PH and Temperature Characteristics of Raw and Filtered Waters:

A.) Following is a tabulation of the results of PH analysis of water samples collected from

NOV.	B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
1	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
2	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
3	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
4	7.1										7.2
5	6.7	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
6											
7											
8	6.3	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
9											
10											
11	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6
12	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
13											
14											
15	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
16	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
17	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
18	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
19	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
20											
21											
22	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
23											
24											
25											
26											
27											
28											
29											
30											
31											
AVG.	7.0										AVG. 7.0
MAX.	7.6										MAX. 7.6
MIN.	6.3										MIN. 6.4

VII. PH and Temperature Characteristics of Raw and Filtered Waters:

A.) Following is a tabulation of the results of PH analysis of water samples collected from November 23 through November 30, 1982

NOV.	B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											
21											
22											
23	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
24	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
25											
26											
27											
28											
29	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
30	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
31											
AVG.	7.0									AVG.	7.0
MAX.	7.1									MAX.	7.1
MIN.	7.0									MIN.	7.0

VII. PH and Temperature Characteristics of Raw and Filtered Waters:

A.) Following is a tabulation of the results of PH analysis of water samples collected from December 1 through December 31, 1982

DEC 1982	B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
1	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
2	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
3	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
4											
5											
6	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
7	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
8	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
9	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
10	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
11											
12											
13	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
14	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
15	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
16	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
17	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
18											
19											
20	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
21											
22	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
23											
24											
25											
26											
27	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
28	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
29	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
AVG.	6.9									AVG.	6.9
MAX.	7.8									MAX.	7.8
MIN.	6.2									MIN.	6.2

VII. PH and Temperature Characteristics of Raw and Filtered Waters:

A.) Following is a tabulation of the results of PH analysis of water samples collected from January 1 through January 31, 1983.

JAN 1983	B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
1											
2											
3	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
4	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
5	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
6	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
7											
8											
9											
10	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
11	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
12	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
13											
14	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
15											
16											
17	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
18	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
19	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
20	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
21	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
22											
23											
24	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
25	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
26	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
27	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
28	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
29											
30											
31	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
AVG.	7.2									AVG.	7.2
MAX.	7.5									MAX.	7.5
MIN.	6.8									MIN.	6.8

VII. PH and Temperature Characteristics of Raw and Filtered Waters:

A.) Following is a tabulation of the results of PH analysis of water samples collected from February 1 through February 22, 1983

FEB 1983	B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
1	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
2	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
3	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
4											
5											
6											
7	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
9	6.7	6.7	6.7	6.7	6.8	6.8	6.8	6.8	6.8	6.8	6.8
10	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
11											
12	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
13											
14	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
15	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
16	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
17	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
18	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
19											
20											
21	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
22	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
AVE	7.05										7.06

AVG.	7.1	AVG.	7.1
MAX.	7.4	MAX.	7.4
MIN.	6.5	MIN.	6.5

VII. PH and Temperature Characteristics of Raw and Filtered Waters:

A.). Following is a tabulation of the results of PH analysis of water samples collected from February 23 through February 28, 1983

F.D.	B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											
21											
22											
23	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
24	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.8	7.8	7.8	7.8
25	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
26											
27	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
28	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
	7.6										7.7
AVG.	7.6									AVG.	7.7
MAX.	7.7									MAX.	7.8
MIN.	7.6									MIN.	7.6

VII. PH and Temperature Characteristics of Raw and Filtered Waters:

A.) Following is a tabulation of the results of PH analysis of water samples collected from March 1 through March 31, 1983

MARCH	B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
1	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
2	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
3	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
4	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
5											
6											
7	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
8	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
9	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
10	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
11	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
12											
13											
14	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
15	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
16	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
17	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
18	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
19											
20											
21	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
22	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
23	7.6	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
24	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
25	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
26											
27											
28	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
29	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
30	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
31	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
AVG.	7.3									AVG.	7.3
MAX.	7.7									MAX.	7.7
MIN.	6.8									MIN.	6.8

VII. PH and Temperature Characteristics of Raw and Filtered Waters:

A.) Following is a tabulation of the results of PH analysis of water samples collected from April 1 through April 29, 1983

APRIL	B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
1											
2											
3											
4	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
5	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
6	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
7	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
8	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
9											
10											
11	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
12	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
13	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
14	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
15	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
16											
17											
18	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
19	7.1										7.1
20	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
21	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
22	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
23											
24											
25	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
26	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
27	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
28	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
29	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
30	—										—
AVG.	7.1									AVG.	7.1
MAX.	7.6									MAX.	7.6
MIN.	6.9									MIN.	6.9

VII. PH and Temperature Characteristics of Raw and Filtered Waters:

A.) Following is a tabulation of the results of PH analysis of water samples collected from May 1 through May 20, 1933

MAY	B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
1											
2	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
3	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
4	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
5	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
6	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
7											
8											
9	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
10	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
11	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
12	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
13	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
14											
15											
16	7.6	7.6	7.6	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
17	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
18	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
19	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
20	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
21											
22											
AVG.	7.3									AVG.	7.3
MAX.	7.6									MAX.	7.6
MIN.	6.8									MIN.	6.8

APPENDIX D pH CHARACTERISTICS

VII. pH and Temperature Characteristics of Raw and Filtered Waters:

A.) Following is a tabulation of the results of pH analysis of water samples collected from May 23 through May 31, 1983.

MAY	B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											
21											
22											
23	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
24	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
25	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
26	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
27	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
28											
29											
30											
31	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
AVG.	7.3									AVG.	7.3
MAX.	7.6									MAX.	7.6
MIN.	7.1									MIN.	7.1

VII. PH and Temperature Characteristics of Raw and Filtered Waters:

A.) Following is a tabulation of the results of PH analysis of water samples collected from

JUNE	B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
1	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
2	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
3	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
4											
5											
6	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
7	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
8	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
9	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
10	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
11											
12											
13	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
14	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
15	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
16											
17	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
18											
19											
20	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
21	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
22	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
23	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
24	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
25											
26											
27											
28											
29											
30											
31											
AVG.	7.5									AVG.	7.5
MAX.	7.8									MAX.	7.8
MIN.	7.2									MIN.	7.2

VII. PH and Temperature Characteristics of Raw and Filtered Waters:

A.) Following is a tabulation of the results of PH analysis of water samples collected from August 1 through August 31, 1983

AUG.	B	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3	F
1	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2
2	8.6	8.5	8.5	8.5	8.3	8.3	8.3	8.3	8.3	8.3	8.3
3	8.8	8.6	8.6	8.6	8.5	8.5	8.5				
4	8.8	8.6	8.6	8.6	8.5	8.5	8.5	8.3	8.3	8.3	8.3
5	8.8	8.8	8.8	8.3	8.4	8.4	8.3	8.3	8.3	8.3	8.3
6											
7											
8	9.4	8.8	8.8	8.8	8.7	8.7	8.7	8.7	8.7	8.7	8.7
9	9.2	8.6	8.6	8.6		8.4	8.4	8.3	8.3	8.3	8.3
10	8.8	8.2	8.2	8.2		7.8	7.8	7.8	7.8	7.8	7.8
11	8.2	7.8	7.8	7.8		7.7	7.7	7.6	7.6	7.6	7.6
12	7.8	7.7	7.7	7.7	7.7	7.7	7.7	7.6	7.6	7.6	7.6
13											
14											
15	8.4	8.0	8.0	8.0	7.8	7.8	7.8	7.7	7.7	7.7	7.7
16	8.6	8.2	8.2	8.2	8.1	8.1	8.1	8.0	8.0	8.0	8.0
17	8.2	7.8	7.8	7.8	7.7	7.7	7.7	7.7	7.7	7.7	7.7
18	8.2	7.8	7.8	7.8	7.7	7.7	7.7	7.6	7.6	7.6	7.6
19	8.2	7.9	7.9	7.9	7.8	7.8	7.8	7.7	7.7	7.7	7.7
20											
21											
22	8.3	7.9	7.9	7.9	7.7	7.7	7.7	7.6	7.6	7.6	7.6
23	8.7	7.9	7.9	7.9	7.8	7.8	7.8	7.7	7.7	7.7	7.7
24											
25	8.6	7.9	7.9	7.9	7.8	7.8	7.8	7.7	7.7	7.7	7.7
26											
27											
28											
29	8.3	7.8	7.8	7.8	7.6	7.6	7.6	7.5	7.5	7.5	7.5
30	8.2	7.8	7.8	7.8	7.6	7.6	7.6	7.5	7.5	7.5	7.5
31	8.0	7.6	8.6	7.6	7.4	7.4	7.4	7.4	7.4	7.4	7.4
AVG.	8.5									AVG.	7.9
MAX.	9.4									MAX.	8.7
MIN.	7.8									MIN.	7.4

B.) Water Temperature: Following is a tabulation of raw water temperatures including climatic conditions which may well affect the temperature. Temperature in °C.

Sept.	Sample Point B °C	Wind Direction	Wind Velocity	Other Conditions
1	20	SW	0-1	Hazy
2	21.5	West	3-5	Cloudy
3	21	NW	5-8	Cloudy
4	21	NW	3-5	Cloudy
5		SW	3-5	Clear
6		SW	3-5	Clear
7	21	NW	1-2	Clear
8	19	NW	1-2	Clear
9	21	SW	0-1	Clear
10	21	NW	0-1	Clear
11'		South	0-1	Clear
12		South	0-2	Clear
13	23	SW	3-5	Hazy
14	23	South	5-8	Clear
15	23	NW	3-5	Rain
16	21	NW	8-10	Cloudy
17	21	NW	3-5	Cloudy
18		NW	3-5	Cloudy
19				
20	18	SW	10-15	Clear
21	19	SW	0-1	Clear
22	19	SW	0-1	Rain
23	18	West	3-5	Cloudy
24	18	SW	3-5	Clear
25		South	0-1	Clear
26		South	0-2	Clear
27	18	NW	0-1	Rain
28	18	NW	0-1	Cloudy
29	18	NW	0-1	Cloudy
30	19	South	5-7	Clear

B.) Water Temperature: Following is a tabulation of raw water temperatures including climatic conditions which may well affect the temperature. Temperature in °C.

OCT 1982	Sample Point B °C	Wind Direction	Wind Velocity	Other Conditions
1	19	S	5-10	Sunny
2		NW	2-3	Cloudy
3		S	5-8	Sunny
4	18	NW	0-2	Sunny
5	18	SW	2-3	Sunny
6	18	SW	0-1	Sunny
7	18.5	SW	3-5	Cloudy
8	18.5	SW	2-3	Sunny
9		W	5	Clear
10		S	4	Clear
11	16	S	10-15	Cloudy
12	15	SW	3-5	Cloudy
13	15	SW	0-1	Overcast
14	15	W	3-5	Cloudy
15	15	SW	5-8	Cloudy
16	13.5	NW	3-5	Cloudy
17		NW	5-8	Sunny
18	11.5	SW	5-8	Cloudy
19	11			
20	11	SW	8-10	Sunny
21	12	W	12-15	Sunny
22	12	NW	0-2	Sunny
23		W	8	Clear
24		S	3	Clear
25	10	SW	0-1	Cloudy
26	10		0-1	Sunny
27	10	SW	2-5	Foggy
28	10	SW	3-5	Sunny
29	11	SW	3-5	Sunny
30		S	0-1	Sunny
31		SW	1-2	Cloudy

APPENDIX E WATER TEMPERATURE

B.) Water Temperature: Following is a tabulation of raw water temperatures including climatic conditions which may well affect the temperature. Temperature in °C.

NOV. 1982	Sample Point B °C	Wind Direction	Wind Velocity	Other Conditions
1	12	SW	1-2	Hazy
2	12	SW	2-3	Sunny
3	14	W	2-3	Cloudy
4	14	NW	3-5	Rainy
5	12			
6		SW	8-10	Cloudy
7				
8	9.5	SW	10-15	Cloudy
9				
10	9.5	SW	0-1	Cloudy
11	9	SW	10-15	Rainy
12	8.5	S	15-20	Cloudy
13		NW	15-20	Cloudy
14	9	SW	0-2	Sunny
15	7	NW	10-15	Cloudy
16	6	SW	3-5	Sunny
17	6	SW	2-3	Sunny
18	6	SW	0-1	Sunny
19	6	SW	10-12	Sunny
20		SW	15-20	Cloudy
21	8	SW	10-15	Cloudy
22	9	W	0-1	Rainy

B.) Water Temperature: Following is a tabulation of raw water temperatures including climatic conditions which may well affect the temperature. Temperature in °C.

NOV.	Sample Point TB °C	Wind Direction	Wind Velocity	Other Conditions
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23	9	SW	3-5	Cloudy
24	9	North	15-20	Rainy
25		NW	10-12	Cloudy
26		SW	5-8	Cloudy
27		NW	2-3	Sunny
28		South	15-20	Cloudy
29	5	SW	5-8	Rain
30	6	SW	0-1	Cloudy
31				

B.) Water Temperature: Following is a tabulation of raw water temperatures including climatic conditions which may well affect the temperature. Temperature in °C.

DEC. 1982	Sample Point TB °C	Wind Direction	Wind Velocity	Other Conditions
1	6	SW	3-5	Cloudy
2	6.5	SW	0-2	Cloudy
3	7	South	10-15	Cloudy
4		NW	3-5	Sunny
5		SW	10-12	Sunny
6	11	SW	10-12	Cloudy
7	9	West	8	
8	9	SW	3-5	Sunny
9	9	NW	5-8	Cloudy-Snow
10	4.5	SW	12	
11		NW	5	
12		NW	11	
13	2	NW	0-1	Sunny
14	3	NW	0-1	Sunny
15	4		0	Cloudy
16	5	NW	10-12	Cloudy
17	2	North	10-12	Cloudy
18		North	0-1	Sunny
19		South	12-15	Cloudy
20	3	North	0-1	Cloudy
21		North	3-5	Snowy
22	4		0	Cloudy
23				
24				
25				
26				
27	6		0	Cloudy
28	9	South	15-20	Cloudy
29	8	NW	0-1	Cloudy
30		West	5-8	Cloudy
31		SW	3-5	

B.) Water Temperature: Following is a tabulation of raw water temperatures including climatic conditions which may well affect the temperature. Temperature in °C.

JAN. 1983	Sample Point TB °C	Wind Direction	Wind Velocity	Other Conditions
1		SW	6-8	
2		SW	4	
3	5	West	15-20	Cloudy
4	4			Sunny
5	3	SW	5-8	Cloudy
6	4	North	0-1	Cloudy
7		West	15-20	Cloudy
8		West	3	
9			0	
10	3	South	25-30	Cloudy
11	4	SW	10-15	Cloudy
12	4	NW	15-20	Snowy
13		NW	5	Snowy
14	2	NW	3-5	Cloudy
15			0-1	Snow
16		NW	3-5	Snowy
17	3	West	12-15	Snow
18	2	NW	20-25	Snow
19	2	NW	2-3	Sunny
20	2	NW	0-1	Sunny
21	2	NW	0-1	Hazy
22		South	0	
23		South	0	Rain
24	2	NW	0-2	Cloudy
25	3	NW	3-5	Cloudy
26	2	North	5-8	Cloudy
27	2	NW	0-1	Sunny
28	2	NW	0-1	Cloudy
29		West	0-1	Sunny
30		South	10-15	Sunny
31	4	SW	12-15	Cloudy

B.) Water Temperature: Following is a tabulation of raw water temperatures including climatic conditions which may well affect the temperature. Temperature in °C.

FEB. 1983	Sample Point TB °C	Wind Direction	Wind Velocity	Other Conditions
1	4	North	3-5	Cloudy
2	4	SE	10-12	Rain
3	4	NW	20-25	Cloudy
4	4	North	15-18	Snow
5		North	8	Snow
6				
7	3	East	0-2	Snow
8	4	NW	10-12	Snow
9	4	NW	0-2	Sunny
10	4	NW	0-1	Sunny
11		NW	0-1	Sunny
12	4	NW	5	
13		NW	0-1	Sunny
14	3	NE	0-1	Sunny
15	4	NW	0-1	Cloudy
16	3	NW	0-1	Sunny
17	3	South	5-10	Cloudy
18	3	NE	3-5	Cloudy
19				
20		SE	0-1	Sunny
21	4	NW	0-1	Sunny
22	5	South	0-1	Cloudy

B.) Water Temperature: Following is a tabulation of raw water temperatures including climatic conditions which may well affect the temperature. Temperature in °C.

MARCH	Sample Point TB °C	Wind Direction	Wind Velocity	Other Conditions
1	5	South	0	
2	5	NW	5	
3	4			
4	5	NW	0	Light Rain
5		West	3	Light Rain
6		South	8	
7	8	South	5	
8	8	South	8	
9	8	South	5	Rain
10	8	NW	3	
11	8	NW	4	Snow
12		North	8	Snow
13		NW	10-12	Sunny
14	5	South	0	
15	6	NW	6	Rain
16	6	West	2	
17	7	SW	10-12	Sunny
18	8	SW	0-2	Cloudy
19		SW	0-1	Cloudy
20		NW	8-10	Cloudy
21	6	West	5	Rain
22	5	West	12	Snow
23	4	West	20-25	Cloudy
24	3	NW	3-5	Sunny
25	3	North	5-8	Sunny
26			0	
27		South	20-25	Snow
28	4	SW	0-1	Cloudy
29	5	North	15-20	
30	4	NW	2-3	Sunny
31	8	SW	2-3	Sunny

B.) Water Temperature: Following is a tabulation of raw water temperatures including climatic conditions which may well affect the temperature. Temperature in ^{0}C.

APRIL	Sample Point TB ^{0}C	Wind Direction	Wind Velocity	Other Conditions
1		SW	0-1	Sunny
2		NW	0-1	Sunny
3		SW	15-20	Cloudy
4	8	South	3	
5	7	SW	0	Cloudy
6	8	SW	2-3	Cloudy
7	9	SW	10-15	Cloudy
8	10	NW	2-3	Cloudy
9		SE	0-2	Sunny
10		West	3	Rain
11	10	NW	5-10	Cloudy
12	9	NW	15-20	Rainy
13	8	South	12-15	Sunny
14	9	South South	25-30 40-45	Cloudy
15	9	South	2-3	Rain
16		North	3-5	Cloudy
17		NW	5-8	Sunny
18	10	North	5-8	Snowy
19	8	North	10-15	Cloudy
20	8	NW	15-18	Cloudy
21		South	0-2	Cloudy
22	7	West	0-1	Foggy
23		South W	4	
24		North	6	Rain
25	7	NW	10-15	Snow
26	7	NW	5	
27	7	SE	3-5	Sunny
28	8		0	
29	9	NW	5-8	Cloudy
30			0-1	Rainy
31				

B.) Water Temperature: Following is a tabulation of raw water temperatures including climatic conditions which may well affect the temperature. Temperature in °C.

MAY	Sample Point TB °C	Wind Direction	Wind Velocity	Other Conditions
1		NW	0-1	Rainy
2	11	SW	20-25	Rain
3				Rain
4	12	NW	5	
5	11	North	10-12	Cloudy
6	11	West	0-1	Sunny
7		South	6	
8		South	5	
9	11	North	20-25	Sunny
10	11	West	15-20	Sunny
11	10	West	0-1	Sunny
12	10	West	0-1	Sunny
13	10	SW	2-3	Sunny
14		SW	3-5	Sunny
15		SW	2-3	Rainy
16	12	NW	10-12	Cloudy
17	11	NW	2	
18	11	SW	3-5	Sunny
19	12	SW	15-20	Cloudy
20	12	SW	8-10	Cloudy
21		South	2	
22		SW	0	

B.) Water Temperature: Following is a tabulation of raw water temperatures including climatic conditions which may well affect the temperature. Temperature in °C.

MAY	Sample Point TB °C	Wind Direction	Wind Velocity	Other Conditions
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23	15	SW	10-12	Sunny
23		West	15-18	Cloudy
24	15	NW	10-12	Cloudy
25	15	SW	10-12	Sunny
26	16			
27	16	SW	8-10	Sunny
28		SW	5-8	Cloudy
29		SW	15-18	Cloudy
30		South	2-3	Sunny
31	17	SW	10-12	Cloudy

B.) Water Temperature: Following is a tabulation of raw water temperatures including climatic conditions which may well affect the temperature. Temperature in °C.

JUNE	Sample Point TB °C	Wind Direction	Wind Velocity	Other Conditions
1	17	West	10-12	Cloudy
2	16	NW	8-10	Sunny
3	17	SW	5-8	Sunny
4		NW	1	Rain
5				Sunny
6	16	NW	8-10	Cloudy
7	18	West	10-12	Sunny
8	18	West	18-20	Sunny
9	17	South	18-20	Sunny
10	17	SW	18-20	Sunny
11		SW	3-5	Sunny
12		SW	5-8	Sunny
13	20	SW	3-5	Sunny
14		West	0-1	Sunny
15	20	SW	3-5	Sunny
16		S	0	-
17	23	S	0	-
18		S	2	Rain
19		S	0	-
20	24	West	1-3	Cloudy
21	24	South	3-5	Sunny
22	23	South	3-5	Sunny
23	25	SW	12-15	Sunny
24	25	NW	3-5	Sunny
25		North	10-12	Sunny
26		South	15-18	Cloudy
27				
28				
29				
30	24	South	4	-
31				

B.) Water Temperature: Following is a tabulation of raw water temperatures including climatic conditions which may well affect the temperature. Temperature in °C.

JULY	Sample Point TB °C	Wind Direction	Wind Velocity	Other Conditions
1		South	3	-
2		SW	8-10	Cloudy
3		South	8-10	Sunny
4		South	10-12	Hazy
5		West	8-10	Cloudy
6	25	NW	15-20	Cloudy
7	23	North	8-10	Sunny
8		South	15-18	Sunny
9		NW	2	Rain
10		NW	5	-
11	25	-	-	-
12	24	South	2	-
13		NW	6	-
14	-	-	-	-
15	-	-	-	-
16		NW	15	-
17		South	0	-
18	26	NW	0-1	Hazy
19	27	NW	0-1	Cloudy
20	27	SW	2-3	Cloudy
21	27	NW	6	Rain
22	26	NW	5	-
23		SW	3-5	Sunny
24		NW	5-8	Sunny
25	24	NW	3-5	Sunny
26	25	West	0-1	Sunny
27	25	South	8-10	Sunny
28	26	West	15-18	Overcast
29	26	South	20-25	Cloudy
30	26	NW	2	-
31		South	2	Rain

B.) Water Temperature: Following is a tabulation of raw water temperatures including climatic conditions which may well affect the temperature. Temperature in °C.

AUGUST	Sample Point TB °C	Wind Direction	Wind Velocity	Other Conditions
1	26	SW	10-12	Rain
2	25	NW	15-18	Sunny
3	26	South	10-12	Sunny
4	26	SW	8-10	Cloudy
5	26	W	0	-
6		West	0	-
7		North	0-1	Sunny
8	27	South	12-15	Sunny
9	27	NW	5-8	Sunny
10	26	West	-	-
11	25	West	0-1	Rain
12	23	NW	5-8	Rain
13				
14		South	5-8	Sunny
15	22	South	10-12	Sunny
16	23	South	0-1	Sunny
17	23	SW	10-12	Hazy
18	25	NW	2-3	Cloudy
19	25	West	-	
20		North	10-12	Cloudy
21		NW	8-10	Sunny
22	24	SW	15-18	Rainy
23	24	North	0-1	Sunny
24		NW	0	-
25	24	SW	2-3	Sunny
26		SW	0	-
27				
28		South	0	-
29	26	West	0-1	Hazy
30	26	SW	3	-
31	25	NW	5-8	Rain